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ABSTRACT

This curriculum guide is designed to help teachers conduct a course that provides senior high school students with the opportunity for in-depth exploration in the field of welding. The course provides students with experiences related to the design, theory, and use of welding systems. The first part of the guide contains such information as course description, target grade levels, general program goals, specific objectives, course flowchart, time frame, and a course outline. Nine teaching guides cover the following units: introduction to welding; safety; identification of metals; oxygen fuel gas welding; oxygen fuel gas cutting; shielded metal arc welding; gas tungsten arc welding; gas metal arc welding; and special projects. Each unit consists of an introduction; competencies; general performance goals/objectives; specific performance objectives and mastery of criteria; methodology; suggested interest approaches; unit outline coordinating subject matter areas and learning activities; unit test; test key; evaluation and testing suggestions; equipment and supplies list; bulletin board ideas; and references. A bibliography lists 22 references and gives names and addresses of sources of equipment and supplies, journals, audiovisuals/computer software, curriculum labs, professional associations, and the Louisiana State Office of Vocational Education. (KC)

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Vocational Education Curriculum Development

BASIC WELDING CURRICULUM GUIDE

Bulletin No. 1859

1989

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BASIC WELDING CURRICULUM GUIDE

PROJECT DIRECTOR

MR. FRED E. BOUCHARD

Funded by
The State of Louisiana
Department of Education
Office of Vocational Education

Southeastern Louisiana University

December 31, 1988

FOREWORD

This publication is a guide for the improvement of instruction in Industrial Arts/Technology Education for the State of Louisiana. It should be of benefit to Industrial Arts/Technology teachers, supervisors, counselors, and administrators. These operational guidelines will help local administrators, teachers, educators, and Industrial Arts/Technology teachers to determine the extent to which their programs are meeting the needs of our youth. Industrial Arts/Technology Education programs must be organized to meet the needs of all students.

A constant concern of educators is the construction and revision of curriculum. Industry and Technology are the core of Industrial Arts/Technology instruction. Both are constantly changing; therefore, curriculum and instruction must change in order to provide students a realistic and accurate understanding of industry and its function in our complex technological society.

Wilmer S. Cody
State Superintendent of Education

ACKNOWLEDGEMENTS

This publication represents the cooperative efforts of the Department of Industrial Technology, Southeastern Louisiana University, Industrial Arts/Technology Instructors, and the Louisiana State Department of Education. Special recognition goes to the project director, Fred E. Bouchard, Southeastern Louisiana University, who was instrumental in the development of this guide and the following curriculum writers: Bill Eischott, Kearnie LaFleur, Craig B. Moore, and Peter A. Ferrito, Jr. Special acknowledgement and thanks goes to David Barron, Southern Enterprises, Ponchatoula, La., for the use of his company's computer-aided drafting equipment. Special thanks to Betty Jo Lawrence for her help in editing and typing this document. Also, thanks to Dr. Florent Hardy, Jr. and Jerry O'Shee, State Department of Education for editing and textual content.

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COURSE DESCRIPTION

This course is designed to provide senior high school students with the opportunity for in-depth exploration in the field of welding. Of primary concern are the various fusion systems and the productive utilization of those systems. Specifically, students are provided experiences related to the design, theory, and utilization of the welding systems.

TARGET GRADE LEVELS

This welding course is designed for senior high school students in grades 10, 11, and 12.

PREREQUISITE

None.

UNITS OF CREDIT

One unit of credit will be allotted to students successfully completing this Basic Welding Course, as per Bulletin 741, the Louisiana Handbook for School Administrators.

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INTRODUCTION

In recent years, great technological advances have been made in the design and application of fusion technology. Processes, equipment, and consumables have changed to keep up with the demand made by our modern society.

Industrial Arts/Technology Education in Louisiana must rise to the occasion and accept the challenges these technological changes have mandated. It is no longer possible to teach a simple course in welding, addressing only oxyacetylene and arc welding. These traditional concepts must be taught, but we must also include instruction in a host of new developments within the areas of fusion processes, components, weld testing and inspection, and automated welding systems. In addition, positive evaluation of student projects must be in relation to established criteria.

Upon inspection of this guide, the teacher will find specified criteria for welding procedures and the evaluation of these procedures along with check sheets for these evaluations.

Students may develop a deep personal interest in the field of welding after becoming confident in their ability to weld and understand the concepts and variables of these operations.

Until students have reached the minimum level of competency as prescribed by this guide, their knowledge would be considered superficial, at best.

TIME FRAME

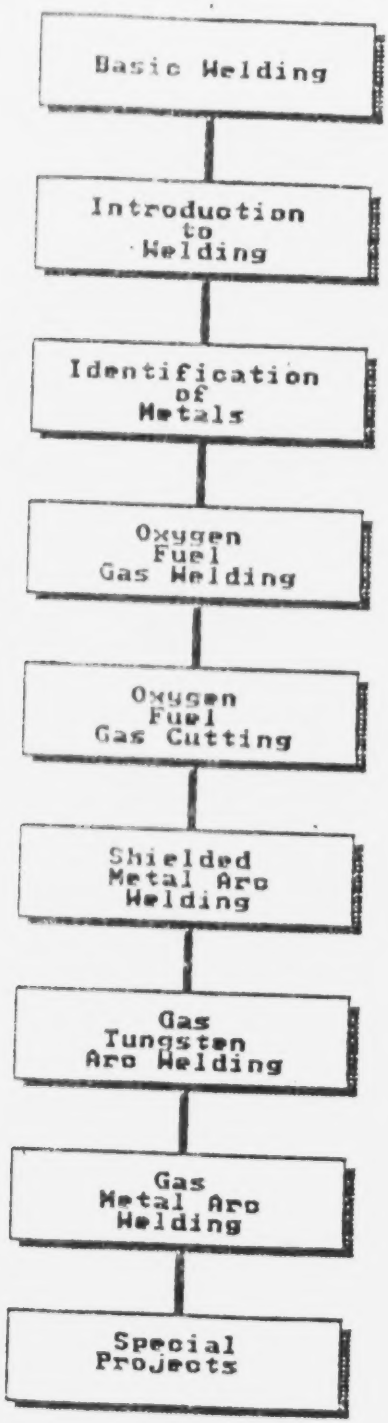
This time schedule is designed to be flexible. Depending on the specialized equipment and materials available, time can be shifted between units.

(1 Wk)	Unit I	Introduction to Welding
(1 Wk)	Unit II	Safety
(1 Wk)	Unit III	Identification of Metals
(4 Wks)	Unit IV	Oxygen Fuel Gas Welding
(6 Wks)	Unit V	Oxygen Fuel Gas Cutting
(6 Wks)	Unit VI	Shielded Metal Arc Welding
(6 Wks)	Unit VII	Gas Tungsten Arc Welding
(6 Wks)	Unit VIII	Gas Metal Arc Welding
(3 Wks)	Unit IX	Special Projects
36 Wks	TOTAL	

TIME PERIOD

55 minutes per day for 36 weeks, or 180 days. Consideration must be given to the opening and closing of school, and other individual school related activities which will ultimately affect the actual time frame.

Course Flow Chart



BASIC WELDING
(COURSE) YEARLY OUTLINE

I. INTRODUCTION

A. Class and Laboratory Management

1. Class procedure
   a. time of class meeting
   b. student responsibility
   c. teacher's responsibility
   d. grading policy

2. Laboratory management
   a. equipment management
   b. duty schedule

B. History of Welding

1. Origins of fusion fabrication

2. Early methods of welding
   a. cast welding
   b. forge welding

3. Today's welding processes

4. Processes of tomorrow

C. Career Opportunities

1. Job interests and attitudes

2. Classification of labor

3. Preparation of welders

4. Upgrading of welding skills

II. SAFETY

A. Introduction to Safety

B. Responsibility for Safety

1. Principal

2. Teacher

3. Student

C. Hazards Associated with the Welding Process

1. Fire hazards
   a. flying sparks
   b. falling slag
   c. hot metal
   d. open flame or arc

2. Burns
   a. hot metal
   b. invisible flames

3. Electric shock
   a. ungrounded equipment
   b. welder becoming part of weld circuit
   c. wet clothing
   d. improper procedures

4. Improper use of pressurized cylinders, regulators, hoses, and torches
   a. faulty equipment
   b. improper usage
   c. wrong equipment selection

5. Radiant energy
   a. ultraviolet rays
   b. infrared rays

6. Gases, fumes, and dust
   a. gases generated by the arc or flame
      1. heat decomposition of cleaning agents, paints, sealants, and lubricants
      2. carbon monoxides
      3. nitrogen oxide
      4. ozone
      5. carbon dioxide
   b. mineral or metallic oxide volatilized by the heating of metal products and associated materials
      1. lead
      2. zinc
      3. cadmium
      4. beryllium
      5. fluorides

D. Protective Clothing and Equipment

1. Clothing
    a. material used
    b. hat
    c. eye protection
    d. shirt
    e. pants
    f. socks
    g. shoes

2. Equipment
    a. shield
    b. respiratory devices
    c. fire extinguisher
        1. class "A"
        2. class "B"
        3. class "C"
        4. class "D"

E. Safety Instruction: A Teacher's Responsibility

1. How to plan for teaching safety

2. Providing safety instruction

3. Enforcement of safety rules

4. Evolving safety instructions

III. METAL IDENTIFICATION

A. Metals Defined in Terms of Properties

1. Mechanical properties
    a. hardness
    b. strength
        1. tensile
        2. compressive
        3. shear
        4. fatigue
        5. impact
        6. flexure
        c. shock resistance
        d. toughness
        e. brittleness
        f. ductility
        g. elongation
        h. wear

2. Chemical properties
   a. corrosion resistance
   b. acid resistance
   c. alkali resistance
   d. other chemicals

3. Electrical properties
   a. conductivity
   b. resistance
   c. dielectric strength

4. Thermal properties
   a. coefficient of thermal expansion
   b. thermal conductivity
   c. melting point

5. Other properties
   a. cost
   b. weight
   c. availability

B. Metal Classification System

1. AISI and SAE
   a. 1st number
   b. 2nd number
   c. 3rd number
   d. 4th number
   e. Percent of carbon

2. Untitled systems
   a. letters
   b. numbers

C. Tests for Metal Identification

1. Appearance

2. Weight

3. Magnetic test

4. Spark test

5. File test

D. Distortion

1. Definition

2. Longitudinal contraction

3. Transverse contraction

4. Angular

5. Factors affecting distortion
   a. joint design
   b. assembly procedure
   c. welding process
   d. deposition technique
   e. welding sequence
   f. unbalanced heat input around a neutral axis

IV. OXYGEN/FUEL GAS WELDING (OFW)

A. Introduction

1. Origin

2. Place in industry

3. Economic significance

B. Equipment Nomenclature and Function

1. Cylinders

2. Manifold system

3. Regulators

4. Hoses

5. Check valves

6. Torch butt

7. Torch tip
   a. welding
   b. heating (rose bud)
   c. cutting

C. Safety Hazards Associated with the OFW Process

1. Cylinder hazard

2. Manifold hazard

3. Regulator hazard

4. Hose hazard

5. Check valve hazard

6. Torch butt hazard

7. Tip hazard
   a. welding tip
   b. heating tip (rose bud)
   c. cutting tip

8. Hot slag

9. Hot metal

D. Consumable Selection

1. Classification

2. Composition

3. Diameter

E. Set Up of Welding System

1. Cylinders

2. Manifold system

3. Regulator

4. Hoses

5. Check valves

6. Torch butt

7. Tip

F. Welding with the OFW System

1. Prelighting setup

2. Light the torch

3. Welding
a. puddling
b. butt weld
c. fillet weld
d. groove weld

G. Weld Defects

V. OXYGEN FUEL GAS CUTTING (OFC)

A. Introduction

1. Origin

2. Place in industry

3. Economic significance

4. Future of the OFC process

5. Safety associated with the OFC process

B. Equipment Nomenclature and Function

1. Cylinders/manifold system
a. regulators
b. hoses
c. check valves
d. torch butt
e. cutting attachment
f. cutting tips
g. automatic movement systems
1. track torch
2. templet trace
3. optic trace
4. CNC

2. Consumable gases
a. oxygen
b. acetylene
c. MAPP

C. Cutting with the OFC Process

1. System assembly

2. Parameter setting

3. Tip selection

4. Purge

5. Light up

6. Cutting
   a. straight cut (hand)
   b. curved cut (hand)
   c. pierce cut (hand)
   d. straight cut (machine)
   e. curved cut (machine)

D. Inspection Criteria

1. Cut lines
   a. straight
   b. kerf

2. No melting (top edge)

3. Vertical drag lines

4. Little slag at bottom

5. Tolerance (± 1/16")

VI. SHIELDED METAL ARC WELDING

A. Introduction

1. Origin

2. Place in industry

3. Economic significance

4. Future of SMAW

5. Safety associated with the SMAW process

B. Equipment Nomenclature and Function

1. Power supplies
   a. transformer
   b. transformer/rectifier
   c. motor driven

2. Consumables
   a. AWS classification
   b. function classification

1. fast freeze
2. fast fill
3. fill freeze
4. low hydrogen

c. diameter criteria

C. Welding with SMAW System

1. Arc strike exercise

2. Stringer bead exercise

3. Stringer bead exercise with various electrodes

4. Weave bead exercise

5. Butt weld (V-groove open root) flat position (1G)

6. Fillet weld horizontal position (2F)

7. Stringer bead horizontal position

8. Butt weld (single V-groove open root) horizontal (2G) position

9. Stringer bead vertical uphand position

10. Weave bead vertical uphand position

D. Inspection Criteria

1. Check list

2. Etched specimens

VII. GAS TUNGSTEN ARC WELDING

A. Introduction

1. Origin

2. Place in industry

3. Economic significance

4. Future of GTAW

B. Equipment Nomenclature and Function

1. Power supplies

2. Coolant source

3. Gas source

4. Cabling

5. Torch
   a. electrode
   b. cups
   c. collets

C. Safety Hazards Associated with GTAW

1. Excessive light generated by the GTAW process

2. Oxygen displacement with welding gas

3. Helium inhalation hazards

4. Hot metal hazard

5. Hot torch hazard

D. Consumable Selection

1. Electrode
   a. classification
   b. composition
   c. diameter
   d. application

2. Gases
   a. classification
   b. composition (mixes)
   c. flow rate
   d. application

E. Setup of GTAW System

1. Power supply

2. Gas supply

3. Flow meter (regulator)

4. Coolant

5. Cabling

6. Torch

7. Electrode

8. Gas cup

F. Welding with GTAW System

1. Equipment preset
   a. amperage
   b. voltage
   c. gas flow
   d. torch cup
   e. electrode
      1. proper angle
      2. proper stick out
   f. coolant

2. Strike arc

3. Welding
   a. padding exercise
   b. corner joint
   c. tee-joint (aluminum)
   d. butt weld (aluminum)
   e. tee-joint (steel)

G. Inspection

1. Visual check (check list)

2. Etching

VIII. GAS METAL ARC WELDING (GMAW)

A. Introduction

1. Origin

2. Place in industry

3. Economic significance

4. Safety

B. Equipment Nomenclature and Function

1. Power supply

2. Wire feeder

3. Gas supply
   a. cylinders
   b. regulators
   c. hoses

4. Water supply (optional)

5. Leads

6. Torch
   a. push
   b. pull

C. Consumables

1. Gases
   a. type
   b. purpose

2. Wire
   a. classification
   b. purpose
   c. diameter

D. Welding with the GMAW System

1. Set up

2. Procedure variables
   a. torch speed travel
   b. direction of torch movement
      1. forehand
      2. backhand
   c. torch angle
   d. nozzle to work distance (stick out)
   e. weave pattern

3. Flat butt weld (steel and aluminum)
   a. materials
   b. consumables
      1. gas
      2. wire
   c. machine set up

d. specimen placement
e. procedure
f. evaluation

4. Horizontal T-joint (steel and aluminum)
   a. materials
   b. consumables
      1. gas
      2. wire
   c. machine set up
   d. specimen placement
   e. procedure
   f. evaluation

IX. SPECIAL PROJECTS

A. Extemporaneous Speech

B. Prepared Speech

C. Research Paper

D. Safety Poster

E. Technical Report Writing

F. Technology Process Display

GENERAL PROGRAM GOALS

In basic welding, the student will have an opportunity to develop skills in welding techniques and understand the concepts and variables of these operations.

SPECIFIC OBJECTIVES

1. To introduce the student to the field of welding and the historical and future perspectives of welding.

2. To identify the basic hazards and safety skills associated with the welding environment.

3. To identify the characteristics of metals being fused and recommend specific methods for welding.

4. To offer students the opportunity to understand the fusion process and identify the manipulative skills needed to accomplish the process.

5. To identify and perform the oxygen fuel cutting process.

6. To develop an understanding of the arc welding process using performance and application techniques.

7. To recognize the advantages of gas tungsten arc welding and be able to perform the GTAW process.

8. To compare the gas metal arc welding process to other welding processes and perform the GMAW process.

9. To define, develop and present projects dealing with safety, process display, and technical speaking.

CURRICULUM GUIDE

UNIT I

INTRODUCTION TO WELDING

INTRODUCTION

The study of welding engages the student in the practical experience of welding or fusion technology. Varied areas may be taught in accordance with the physical plan of the laboratory and the economic situation of the school. Laboratory experimentation and application of welding principles are used to reinforce the theoretical units. This laboratory experience is designed to give students an appreciation for welding in our society, an understanding of the physical, mechanical and chemical bonding, and an opportunity to develop skill in accomplishing the processes of fusion technology.

COMPETENCIES

1. Develop an interest in and introduce the students to the field of welding.

2. Acquire knowledge of the historical and future perspectives of welding.

GENERAL PERFORMANCE GOALS/OBJECTIVES

1. The students will develop an understanding of class management.

2. Develop an understanding and appreciation for the historical development of fusion technology related to the field of welding.

3. Analyze the employment opportunities available within the field of fusion technology as related to welding.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY OF CRITERIA

1. Given the proper reference material, lecture, and discussion, the students will be able to state rules and regulations for the efficient management of the laboratory, with an accuracy of at least 75%.

2. On a written examination, the students will explain the present and future historical perspectives in welding and fusion technology, with an accuracy of 75%.

3. On a written examination, the students will be able to list the necessary attitudes to succeed in the field of welding, with an accuracy of 75%.

4. On a written examination, the students will explain the employment opportunities available in the field of welding, with an accuracy of 75%.

METHODOLOGY

This unit will introduce the students to fusion technology - specifically welding. Emphasis will be placed on the historical development of welding processes and how these processes are accomplished in today's industry. Method of teaching to be employed will include lecture, audiovisual, library research, guest speakers, field trips, textbooks, discussion, and testing.

SUGGESTED INTEREST APPROACHES

1. Students will participate in research of the historical development in the field of welding.

2. Obtain a guest speaker that will emphasize the need for welding in today's society.

3. Audiovisuals from welding equipment manufacturers; show new and innovative application techniques that are present today in industry.

UNIT I OUTLINE

INTRODUCTION

I. Class and Laboratory Management

A. Class procedure
1. time of class meeting
2. student responsibility
3. teacher's responsibility
4. grading policy

B. Laboratory management
1. equipment management
2. duty schedule

II. History of Welding

A. Origins of fusion fabrication

B. Early methods of welding
1. cast welding
2. forge welding

C. Today's welding processes

D. Processes of tomorrow

III. Career Opportunities

A. Job interests and attitudes

B. Classification of labor

C. Preparation of welders

D. Upgrading of welding skills

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. Given the proper reference material, lecture, and discussion, the students will be able to state rules and regulations for the efficient management of the laboratory, with an accuracy of at least 75%.

Subject Matter Content	Learning Activities
Laboratory and Classroom Management	1. Hand out and discuss a list of policies for laboratory and class management. 2. Discuss the organization of tools, equipment, and work area within the laboratory. 3. Discuss importance of compliance with rules in the welding laboratory. 4. Construct bulletin board poster depicting laboratory rules and regulations.

2. On a written examination, the students will explain the present and future historical perspectives in welding and fusion technology, with an accuracy of 75%.

Subject Matter Content	Learning Activities
Historical, Present and Future Aspects of Welding	1. Research and present a report on the history, present and future of welding. 2. Present audiovisual material on present and future applications of welding.

3. Invite a guest speaker to discuss the importance of welding today and future applications.

3. On a written examination, the students will be able to list the necessary attitudes to succeed in the field of welding, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Work Attitude	1. Define attitude in terms of what is required for success in the welding field.
	2. With student participation, develop a list of attitudes that would be essential for successful employment in the welding field.
	3. With student participation, develop a list of attitudes that would prove detrimental to successful employment in the welding area.
	4. View audiovisual material depicting positive and negative work habits in the adult work place.

4. On a written examination, the students will explain the employment opportunities available in the field of welding, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Division of Labor and Career Opportunities in the Field of Welding	1. List classifications of workers found in the field of welding. Develop lists of

duties and responsibilities required at each level and classification.

2. View audiovisual media depicting careers in welding and degree of training required at each level.

UNIT TEST

INTRODUCTION

1. List general rules that must be addressed in the welding laboratory.

2. How has welding affected the evolution of our civilization?

3. List 5 categories of labor found in the welding field.

4. What trends are being reorganized in welding today?

5. What is the future of welding?

UNIT TEST KEY

INTRODUCTION

1. a. Keep work area clean.
   b. Put tools away upon completion of task.
   c. Do not manipulate switches or valves without the instructor's knowledge and permission.
   d. Know the location of electrical circuit breakers and the procedure for emergency shut down.
   e. Know the location of fire extinguishers and the path for emergency evacuation.

2. There is hardly any human activity that does not depend upon welding.

3. Welding Engineer
   Welder
   Welding Inspector
   Welding Helper
   Tacker
   Weld Cutter

4. Trends - Automated Systems -
   Special Processes
   New Materials

5. Welding in the Future
   Welding of exotic materials
   Welding in space
   Robotic and automated means

EVALUATION AND TESTING

Ways to evaluate student growth

1. Unit test.
2. Class assignment.
3. Procedural test.
4. Participation in class projects.
5. Comparison of student work to approved standards.

EQUIPMENT AND SUPPLIES

Student

Textbook
Workbook (if applicable)
Handouts
1. Laboratory procedures
2. Student responsibilities

Pen/Pencil

Teacher

Textbook
Workbook
Teacher's Manual
Overhead Projector
Curriculum Guide
Audiovisual Aids
Projector
Models

BULLETIN BOARD IDEAS

1. Display student-developed ideas of positive and negative attitudes related to employment in the welding field.

2. Organizational and management policies.

3. Historical and futuristic applications of welding.

4. Division of labor as found in welding field.

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UNIT II

SAFETY

INTRODUCTION

To work effectively, today's industrial arts students must be able to operate modern industrial tools and equipment safely. This unit will pertain to the concept of safety as dictated by the concept of fusion technology.

COMPETENCIES

1. Identify basic hazards found in the welding laboratory.

2. Master the basic safety skills associated with the welding environment.

3. Understand the rationale and requirement of the special conditions, clothing, and housekeeping as mandated by processes of welding.

GENERAL PERFORMANCE GOALS/OBJECTIVES

1. Give examples of disasters, loss of property, and injury caused by the careless use of welding equipment.

2. Develop an understanding of the potential hazards associated with the process of welding.

3. Develop an understanding of precautions, safety equipment and attitudes required to minimize the potential hazard associated with the welding process.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will be able to list the hazards associated with the welding environment as manifested in the laboratory, with an accuracy of 100%.

2. On a written examination, the students will be able to state the precautions and rationale needed to confront the hazards of welding as found in the laboratory, with an accuracy of 100%.

3. On a written examination, the students will be able to match the welding hazard with the appropriate response to that hazard, with an accuracy of 100%.

METHODOLOGY

This unit is designed to present students with the safety principles appropriate to the welding environment. Throughout this lesson, emphasis will be placed on the utilization of the appropriate personal protective devices and the adherence to prescribed safety procedures necessary to perform the welding task. The instructor will utilize frequent lab demonstrations to illustrate safety concepts discussed in the class lecture.

SUGGESTED INTEREST APPROACHES

1. Demonstrate safe operation of tools.

2. Demonstrate correct procedures to perform the various operations.

3. Demonstrate correct responses to hazards as found in the welding environment.

4. Audiovisual coverage of welding hazards and responses.

5. Invite guest speakers to demonstrate safety equipment and speak on safety.

6. Review current federal, state and local laws and publications pertaining to industrial safety and the welding environment.

UNIT OUTLINE

SAFETY

I. Introduction to Safety

II. Responsibility for Safety

A. Principal

B. Teacher

C. Student

III. Hazards Associated with the Welding Process

A. Fire hazards
1. flying sparks
2. falling slag
3. hot metal
4. open flame or arc

B. Burns
1. hot metal
2. invisible flames

C. Electric shock
1. ungrounded equipment
2. welder becoming part of weld circuit
3. wet clothing
4. improper procedures

D. Improper use of pressurized cylinders, regulators, hoses, and torches
1. faulty equipment
2. improper usage
3. wrong equipment selection

E. Radiant energy
1. ultraviolet rays
2. infrared rays

F. Gases, fumes, and dust
1. gases generated by the arc or flame
a. heat decomposition of cleaning agents, paints, sealants, and lubricants
b. carbon monoxides
c. nitrogen oxide

d. ozone
e. carbon dioxide

2. mineral or metallic oxide volatilized by the heating of metal products and associated materials
   a. lead
   b. zinc
   c. cadmium
   d. beryllium
   e. fluorides

IV. Protective Clothing and Equipment

A. Clothing
   1. material used
   2. hat
   3. eye protection
   4. shirt
   5. pants
   6. socks
   7. shoes

B. Equipment
   1. shield
   2. respiratory devices
   3. fire extinguisher
      a. class "A"
      b. class "B"
      c. class "C"
      d. class "D"

V. Safety Instruction: A Teacher's Responsibility

A. How to plan for teaching safety

B. Providing safety instruction

C. Enforcement of safety rules

D. Evolving safety instructions

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. On a written examination, the students will be able to list the hazards associated with the welding environment as manifested in the laboratory, with an accuracy of 100%.

Subject Matter Area	Learning Activities
Hazards of Welding	1. Using lecture, audio-visual presentations, and demonstrations, the instructor will introduce the students to the five principle hazards associated with the welding process. a. Fire hazards b. Electric shock and burns c. Improper use of cylinders, regulators, hoses, and torches d. Radiant energy e. Gases, fumes, and dust

2. On a written examination, the students will be able to state the precautions and rationale needed to confront the hazards of welding as found in the laboratory, with an accuracy of 100%.

Subject Matter Area	Learning Activities
Personal Protective Equipment	1. Using lecture, audio-visual presentations, and demonstrations, the instructor will introduce the students to personal safety equipment by demonstrating its proper use, fit, maintenance, and rationale.

The basic equipment that should be addressed is:

a. Eye protection
   1. grinding
   2. chipping
   3. arc protection
   4. gas welding protection
b. Clothing
   1. long sleeves
   2. long pants
   3. socks
   4. shoes
   5. hat
   6. gloves

3. On a written examination, the students will be able to match the welding hazard with the appropriate response to that hazard, with an accuracy of 100%.

Subject Matter Area	Learning Activities
Protective Equipment and Procedures	1. Utilizing audio-visual, lecture and demonstration, the instructor will identify personal safety equipment and demonstrate its function, fit, and maintenance.

UNIT TEST

SAFETY

Each teacher is to develop and administer a safety exam specifically for their welding course. Because of the extreme variance in the lab organization and layout, the tools and equipment therein, and the actual course content, only that specific teacher can develop a valid safety exam.

The teachers should develop questions for the exam from their lectures. School system rules and regulations, and the material found in Bulletin 1674, General Safety Manual for Vocational Technical Education and Industrial Arts Programs, issued by the Office of Vocational Education, Louisiana State Department of Education, are also of great use in developing both lessons and exams. These are included in this unit for reference.

The teacher-generated exam should be as thorough and comprehensive as the lectures. Students must be required to perform satisfactorily on the teacher-generated safety exam before they are permitted to work in the lab.

*From Bulletin 1674, General Safety Manual for Vocational Technical Education and Industrial Arts Programs, Louisiana State Department of Education.

SAFETY TEST FOR OXYGEN-ACETYLENE WELDER

Name: _____ Class: _____

Date: _____

I. Multiple Choice: For each item below select the one best answer. Then write the letter that represents your choice on the line to the left of each item.

_____ 1. You should make sure the welding equipment is:
A. lubricated with oil
B. tightened by hand
C. kept free of oil and grease
D. lubricated weekly

_____ 2. Welding goggles are worn because they:
A. magnify your work
B. protect your eyes from dust
C. help you concentrate on your work
D. protect your eyes against heat, rays, and sparks

_____ 3. The valve on a cylinder of acetylene should be opened:
A. with a pair of pliers
B. three full turns
C. three-fourths of a turn or less
D. as many turns as possible

_____ 4. When you light a welding torch, you should use:
A. a friction torch lighter
B. a match
C. a fluid lighter
D. a piece of lighted paper

_____ 5. If a welding torch backfires, you should:
A. dip the torch in water
B. inspect the hose
C. hang an out-of-order sign on the equipment
D. close the acetylene valve first

II. <u>True-False</u>. If you believe the statement is true, circle the "T." If you believe it is false, circle the "F."

T F 1. Gas bottles may be laid on the floor when not in use.

T F 2. Closed containers are not hazardous to weld or repair.

T F 3. The cylinder caps should be placed on all bottles when not in use.

T F 4. Eye protection must be worn for all welding, cutting and chipping operations.

T F 5. The equipment should not be wiped down with oily rags.

T F 6. Acetylene pressure should be set at 20 psi.

UNIT TEST

OXYGEN-ACETYLENE WELDER

ANSWER KEY

Multiple Choice:

1. C
2. D
3. C
4. A
5. D

True-False:

1. F
2. F
3. T
4. T
5. T
6. F

*From Bulletin 1674, General Safety Manual for Vocational Technical Education and Industrial Arts Programs, Louisiana State Department of Education.

SAFETY TEST FOR ELECTRIC ARC WELDER

Name: _____ Class: _____

Date: _____

I. Multiple Choice. For each item below, select the one best answer. Then write the letter that represents your choice on the line to the left of each item.

_____ 1. The observation window in your welding helmet is cracked. It will:
A. allow dust to pass through it
B. obstruct your view
C. transmit infrared and ultraviolet rays
D. rattle every time the helmet is flipped

_____ 2. When you are through using the electrode holder, you should:
A place it on a metal workbench
B. clamp it on the metal frame of the workbench
C. rest it on the floor
D. suspend it so it will not touch any metal

_____ 3. If a cable or the electrode holder overheats, you should:
A. notify your instructor
B. turn the voltage down
C. stop welding and wait until it cools
D. change the electrode holder

_____ 4. You should always draw the curtains on the welding booth before you strike an arc so as to:
A. protect your eyes from the infrared and ultraviolet rays
B. keep the work from getting cool
C. prevent anyone from noticing any mistakes
D. protect anyone nearby from the infrared and ultraviolet rays

_____ 5. Before leaving heated metal unattended, you should use chalk or soapstone to label it with the word "hot" because:
A. students may be burned if they touch it
B. other work may be placed on it
C. you can tell to whom it belongs
D. chalk will help cool it

II. Fill in the blanks.

1. For eye protection against infrared and ultraviolet rays, you must wear a welding _____ _____.

2. When chipping slag, you must wear _____ _____.

3. Arc welding should be done only behind proper screens or in a _____ _____.

4. If your skin is exposed to electric arc rays, you will be _____ _____.

5. A _____ should be near when electric welding.

6. The welding area should be well _____ _____.

UNIT TEST

ELECTRIC ARC WELDER

ANSWER KEY

Multiple Choice:

1. C
2. D
3. A
4. D
5. A

Fill-in-the-blanks:

1. shield
2. eye protection
3. welding booth
4. sunburned
5. fire extinguisher
6. ventilated

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit test.
2. Quizzes at critical times.
3. Safety poster.
4. Safety performance.
5. Class assignments.

EQUIPMENT AND SUPPLIES

Student	Teacher
Pencil	Chalkboard, chalk, eraser
Notebook	Audiovisual equipment
Textbook	Textbook
Safety glasses	Lesson plan
Safe clothing	Curriculum guide
	First aid kit
	Fire extinguisher
	Safety devices to demonstrate
	Safety glasses

BULLETIN BOARD IDEAS

1. Post safety rules for welding.
2. Post accident report form.
3. Post safety inspection checklist.
4. Display commercial safety posters.
5. Display students' safety posters.

SAFETY RULES AND REGULATIONS

General Safety Instructions

1. No horse-playing or any practical joking in any shop area.
2. Never take chances.
3. Observe all posted safety notices and posters.
4. Know where fire extinguishers are located and how to use them.
5. Insure that the ventilation system is operating for your work station or area.
6. Secure approval of your instructor on all work you plan to do. This applies to all projects and assignments in which you use shop equipment and tools.
7. Report immediately to your instructor upon incurring any injury, even though slight.
8. Caution any person you see violating a safety rule.
9. Report to the instructor any equipment that does not seem to work properly.
10. Keep tools and materials from projecting over the edge of benches, whenever possible, so no one will walk into them and get injured.
11. Follow prescribed safety instructions in handling large, heavy, and long pieces of material. In general, never carry anything over six feet in length or over 50 pounds in weight without assistance.
12. Practice designated procedures to use in case of earthquake, fire, or other emergencies.
13. Walk, do not run, in all shop areas.
14. Be considerate of the safety of others.
15. Adhere to safety rules pertinent to a specific shop.
16. Report unsafe conditions to the instructor.

17. Never throw any object in the shop; an accident or an injury may result.

18. Never use compressed air for other than specified purposes.

19. Make certain hands and tools are free of oil and grease.

20. Clean work stations and place tools in proper areas at the end of each class period.

21. Study fire regulations pertinent to the shop so that you can assist in closing windows, making proper exits, etc.

22. If you feel ill, do not operate a machine. Report to your instructor.

23. Use proper lifting techniques when moving heavy objects.

24. Never treat or remove particles from the eye. See your instructor or school health personnel for immediate attention.

Safety Instructions for Personal Protection

1. Wear proper eye protection while participating in activities that may endanger your eyes.

2. Be sure clothes are safe and suitable for shop work. Remove or fasten any loose clothing. Roll sleeves above your elbows. Keep hair away from equipment in operation. Students with long hair must confine it in hair nets or caps when around tools and equipment.

3. Rings, bracelets, watches and any other jewelry must be removed when working in labs/shops.

4. Wear gloves when materials such as rough boards, metals subject to burrs or sharp edges, glass, or other such materials are handled.

5. Wear protective clothing and equipment for the use it is intended. Avoid wearing gloves or anything else that may be pulled into a machine.

6. Wear a respirator when harmful dust or fumes exist.

7. Use face shields during hazardous operations in cutting metal, wood, or similar material.

8. Never use flammable liquids for cleaning purposes.

9. Wear rubberized protective equipment when working with electricity.

10. Wear ear protection when excessive noise is encountered.

11. Wear helmet and hand shields when performing operations that produce intense radiant energy like arc welding and heavy gas cutting.

12. Wear canvas or heavy cotton work gloves for operations when the main hazards are blisters caused by friction. When heat is involved, like foundry work, a more protective type of glove or mitten should be worn.

13. Wear safety shoes with steel toes when lifting heavy objects or working around them.

14. Shop coats, aprons, or coveralls should be worn for general body protection against dirt and grease.

15. Remove ties when working around machine tools or rotating equipment.

16. Use soap and water frequently as a method of preventing skin disease.

Safety Instructions for Use of Equipment and Tools

1. Use the right tools for the job.

2. Never leave a machine while it is running.

3. Observe rules governing operator's zones around tools and machines.

4. Use a brush or piece of wood to clear away dry chips from your machine bench. (The machine must have been turned off and come to a complete stop.)

5. Secure permission from your instructor for using machines and have special set-ups approved.

6. Do not use tools or equipment until instruction relative to safe handling has been given.

7. Person not operating power tools or assisting in the operation thereof, should keep clear of the machine and operator.

8. Do not stop or start a machine for another person except in an emergency.

9. Machines must be operated by only one person at a time.

10. Do not use machines for trivial operations, or when hand tools would best accomplish the task.

11. Do not tamper with adjustments or play with machinery at any time. Serious accidents may result.

12. Do not lean on machines. You may press a switch or throw a control which, upon starting, could endanger the safety of the operator or damage the machine.

13. Stop all power machinery to oil, adjust, or clean.

14. Allow revolving machinery to stop on its own. Resist the desire to grab chucks, spindles, or other rotating parts with the hand.

15. Use power tools only when your instructor is present in the room.

16. Set up shields to stop flying chips, sparks or particles.

17. Replace grinding wheels showing cracks, those out of balance, or those worn too small to allow proper clearance (not more than 1/8") between the tool rest and stone.

18. Keep cutting tools sharp.

19. Never mount a grinding wheel unless the speed of the motor and the speed of the wheel are known and the two are appropriate.

20. When starting a machine, allow it to reach its operating rpm before using it.

21. When finished with a tool, clean and return it to its proper location.

22. Ensure that vise handles hang free when not in use.

23. Know and follow the specific requirements of the kind and type of machine you are operating.

24. Enclose all gears, moving belts, and other power transmission devices, or erect barricades to prevent contact.

25. Operate equipment only after passing a test for safe operation of that machine.

26. Do not use defective tools, machines, or other equipment.

27. Do not remove guards and safety devices.

28. Observe specific safety zones designated by the instructor and become familiar with color codes.

29. Do not talk with other students while operating machines.

30. Observe safety rules posted at or near potentially hazardous machines.

31. Do not operate any machine until you have received proper instruction, and fully understand how to operate it.

32. Have your instructor check special machine set-ups.

33. Check on machines and make all adjustments before turning on the power.

34. Make sure other persons are clear before turning on the power.

35. Be sure the guards are in place and function properly.

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UNIT III

IDENTIFICATION OF METALS

INTRODUCTION

To successfully accomplish the joining process of welding, the students must have an understanding of the nature and characteristics of the metals being fused. Among the metals commonly welded in Louisiana are cast iron, steel, stainless steel, brass, and aluminum alloys. The physical and mechanical properties of these metals are a basic determinant in selecting the appropriate fusion method.

COMPETENCIES

1. Students will be able to discuss the important properties of metals.
2. Students will be able to identify metals according to the four basic tests.
3. Students will be able to recommend specific methods for welding the various metals studied.
4. Students will be able to describe the AISI and SAE metal classification systems.
5. Students will be able to prescribe various procedures used to prevent metal distortion.

GENERAL PERFORMANCE OBJECTIVES/GOALS

1. Give examples of the various properties of metals according to AISI standards.
2. Be able to identify the various metals by common test methods.
3. Be able to discuss the various types of distortion and present methods of controlling distortion.
4. Be able to discuss how the carbon content of steel affects its properties.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will be able to match the major metallurgical category of metal to the specific property exhibited by that metal, with an accuracy of 80%.

2. Given samples of cast iron, stainless steel, low carbon steel, high carbon steel, aluminum, brass, and copper, the students will be able to identify the metals using one or more of the following tests: appearance, weight, spark test, file test, and magnetic test, with an accuracy of at least 75%.

3. On a written examination, the students will be able to match the AISI and SAE material designations with the type of material and carbon content, with a 75% accuracy.

4. On a written examination, the students will be able to match the graphic representations of the types of distortion with the correct name and probable cause, with a 75% accuracy.

METHODOLOGY

This unit will present the students with important information concerning the kinds of metals, their identification and classification, their properties, and appropriate means to fuse the various metals while controlling their deformation. The primary means for delivery will be the lecture-demonstration approach. As there is insufficient time for each student to experiment in this area, the instructor will provide the appropriate demonstrations. Care should be taken to emphasize to the students that the factors learned in this unit will apply to each welding process presented during the remainder of this Basic Welding course.

SUGGESTED INTEREST APPROACHES

1. Show a film on the identification and testing of metals.

2. Invite a guest speaker from a local materials testing lab to speak to the class.

3. Have the students generate posters depicting the various properties and methods of testing metals.

4. Have the students prepare a research paper and give a brief presentation on the properties and testing of metals.

UNIT OUTLINE

METAL IDENTIFICATION

I. Metals Defined in Terms of Properties

A. Mechanical properties
   1. hardness
   2. strength
      a. tensile
      b. compressive
      c. shear
      d. fatigue
      e. impact
      f. flexure
   3. shock resistance
   4. toughness
   5. brittleness
   6. ductility
   7. elongation
   8. wear

B. Chemical properties
   1. corrosion resistance
   2. acid resistance
   3. alkali resistance
   4. other chemicals

C. Electrical properties
   1. conductivity
   2. resistance
   3. dielectric strength

D. Thermal properties
   1. coefficient of thermal expansion
   2. thermal conductivity
   3. melting point

E. Other properties
   1. cost
   2. weight
   3. availability

II. Metal Classification System

A. AISI and SAE
   1. 1st number
   2. 2nd number
   3. 3rd number
   4. 4th number
   5. Percent of carbon

B. Untitled systems
   1. letters
   2. numbers

III. Tests for Metal Identification

A. Appearance

B. Weight

C. Magnetic test

D. Spark test

E. File test

IV. Distortion

A. Definition

B. Longitudinal contraction

C. Transverse contraction

D. Angular

E. Factors affecting distortion
   1. joint design
   2. assembly procedure
   3. welding process
   4. deposition technique
   5. welding sequence
   6. unbalanced heat input around a neutral axis

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. On a written examination, the students will be able to match the major metallurgical category of metal to the specific property exhibited by that metal, with an accuracy of 80%.

Subject Matter Area	Learning Activity
Properties of Metal	1. Through the use of chalkboard, overhead transparencies and laboratory demonstration, the following properties will be demonstrated and discussed in terms of the welding processes: a. Hardness b. Brittleness c. Strength 1) tensile 2) compression 3) shear 4) fatigue 5) flexure d. Thermal 1) thermal conductivity 2) melting point 3) coefficient of expansion 2. If possible, have the students practice testing metals which they will soon be welding.

2. Given samples of cast iron, stainless steel, low carbon steel, high carbon steel, aluminum, brass, and copper, the students will be able to identify the metals using one or more of the following tests: appearance, weight, spark test, file test, and magnetic test, with an accuracy of at least 75%.

Subject Matter Area	Learning Activity
Identification of Metals	1. Present a lecture on the common methods of identifying metals. 2. Demonstrate the following tests: Spark Test Magnetic Test File Test Appearance Test Weight Test 3. Working with small groups, explain the mechanics of the test and the interpretation of the results. 4. Let students perform tests on unknown samples and identify specimens.

Note: Before students use the grinder:

1. The students must be checked out on the grinder in accordance with State Curriculum Guide for Safety in the Industrial Arts Laboratory.
2. The students must wear the appropriate eye protection while accomplishing the identification tests.

3. On a written examination, the students will be able to match the AISI and SAE material designations with the type of material and carbon content, with a 75% accuracy.

Subject Matter Area	Learning Activity
Identification of Material Classification Numbers	1. With the use of audiovisual aids or chalk board presentation reinforced by hand-outs, discuss the derivation of the four digit numbering system of the AISI and SAE systems.
	2. Write various designations on the chalkboard and have the students practice their identification.

4. On a written examination, the students will be able to match the graphic representations of the types of distortion with the correct name and probable cause, with a 75% accuracy.

Subject Matter Area	Learning Activity
Distortion	1. Discuss the forms of distortion in class lecture.
	2. Demonstrate the three forms of distortion in the laboratory.

Note: Students must wear correct eye protection when viewing this procedure.

3. Discuss what procedures can be used to minimize the effect of the three types of distortion. Factors to be discussed should be:
   a. Joint design
   b. Parent metal
   c. Assembly procedure
   d. Welding processes
   e. Deposition technique
   f. Balanced heat put about a neutral axis
   g. Restraint

UNIT TEST

IDENTIFICATION OF METALS

PART I. True or False:

_____ 1. Cast iron produces a red spark close to the wheel on a spark test.

_____ 2. Aluminum produces no spark on a spark test.

_____ 3. High carbon steel produces a low volume of sparks on a spark test.

_____ 4. High carbon steel produces red sparks on a spark test.

_____ 5. Aluminum is magnetic.

_____ 6. Aluminum can be cut with a file easier than stainless steel.

_____ 7. Copper and brass are the same color.

_____ 8. Stainless steel is heavier than aluminum.

_____ 9. High carbon steel cuts easier than low carbon steel in the file or scratch test.

_____ 10. Copper and brass are magnetic.

_____ 11. A 1018 steel is low carbon steel.

_____ 12. A 1018 steel is more ductile than a 1090 steel.

_____ 13. A 11XX number in steel classification refers to a free cutting carbon steel.

_____ 14. A 1093 steel has an alloy agent of molybdenum.

_____ 15. Lead, sulfur, and tellurium give carbon steel better machinability.

_____ 16. Low carbon steel has .05-.35% carbon.

_____ 17. Fence wire is an application for low carbon steel.

_____ 18. Low carbon steel has a greater strength to weight ration than does maraging steel.

_____ 19. Maraging steel has an 18-25% nickel content.

_____ 20. Quench temper structural steels are more expensive than low alloy structural steels.

_____ 21. Low carbon steels are heat treatable.

_____ 22. Low carbon steel can be hardened by work hardening.

_____ 23. All stainless steel has a high content of chromium.

PART II. Matching I: Match the alloy to the characteristic it gives to carbon steel.

A. carbon
B. vanadium
C. nickel
D. chromium
E. aluminum

_____ 24. Hardness

_____ 25. Hardenability

_____ 26. Corrosion resistance

_____ 27. Deoxidation

_____ 28. Fine grain

_____ 29. Toughness

Matching II: Match the alloy to the characteristic it gives to carbon steel.

A. copper
B. lead
C. manganese
D. tungsten
E. cobalt

_____ 30. Machinability

_____ 31. High temperature strength

_____ 32. Strength

_____ 33. Hardness

_____ 34. Corrosion resistance

UNIT TEST

ANSWER KEY

IDENTIFICATION OF METALS

True or False:

1. T
2. T
3. F
4. F
5. F
6. T
7. F
8. T
9. F
10. F
11. T
12. T
13. T
14. F
15. T
16. T
17. T
18. F
19. T
20. T
21. F
22. T
23. T

Matching I:

24. A
25. D
26. D
27. E
28. B
29. C

Matching II:

30. B
31. D
32. C
33. E
34. A

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit exam.
2. Quizzes.
3. Student report/presentation.
4. Student posters.

EQUIPMENT AND SUPPLIES

Student	Teacher
Pencil	Chalkboard, chalk, eraser
Notebook	Audiovisual equipment
Textbook	Textbook
Safety glasses	Lesson plan
Safe clothing	Curriculum guide
	Safety glasses
	Samples of various metals which the students will weld in the coming year

BULLETIN BOARD IDEAS

1. Display information concerning the metals the students will weld in the coming year.
2. Post lab safety rules.
3. Post AWS, AISI, and SAW metals identification criteria.
4. Display student posters.
5. Display samples of various metals.

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UNIT IV

OXY/FUEL GAS WELDING

(OFW)

INTRODUCTION

Oxygen fuel gas welding, being one of the older methods of welding, still has a wide range of uses in today's industrial arena. Oxygen fuel gas welding (OFW) is a fusion welding process that utilizes a fuel gas in combination with pure oxygen to increase the thermal energy to produce heat with sufficient thermal energy to cause metal to be melted (fusion) or burned (oxidized) depending upon equipment and process used.

Students who wish to participate in the present and future industrial arena must have an understanding of the fusion process. OFW offers students the opportunity to understand fusion and develop the manipulative skills needed to accomplish this process.

COMPETENCIES

1. Understand the fusion process as created by the OFW process.
2. Master the terms and language unique to the OFW process.
3. Understand the safe use of OFW concepts and equipment.
4. Understand the principle of industrial gases and pressure cylinders as they pertain to the concept of OFW.
5. Understand the rationale behind the adjustments of regulators associated with OFW equipment.

GENERAL PERFORMANCE OBJECTIVES/GOALS

1. Identify by name and function the equipment utilized in the OFW process.

2. Be able to identify the hazards associated with the OFW process.

3. Be able to correctly assemble an OFW system, as a single tank unit and as a manifold system.

4. Develop skills in the selection and use of OFW equipment.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will be able to list and describe the advantages and disadvantages of the OFW process, with an accuracy of 75%.

2. On a written examination, the students will demonstrate their ability to name and state the function of the OFW equipment, with an accuracy of 75%.

3. On a written examination, the students will be able to list the hazards associated with the OFW process and the appropriate procedures and/or equipment necessary to negate those hazards, with an accuracy of 75%.

4. On a written examination, the students will be able to list and explain the rules pertaining to the storage and use of the various pressurized oxy/fuel cylinders, with an accuracy of 75%.

5. On a demonstrative test, the students will demonstrate their ability to correctly assemble an OFW system, with an accuracy of 75%.

6. On a written examination, the students will demonstrate their ability to select the proper tip for a given situation, with an accuracy of 75%.

7. On a demonstrative test, the students will demonstrate the correct procedure to turn on gas supplies, correctly set regulators, and to light and adjust the torch to produce a neutral flame, with an accuracy of 75%.

8. On a demonstrative test, the students will perform a butt weld, a fillet weld on a Tee-joint, and a groove weld utilizing the OFW process to the specified criteria, with an accuracy of 75%.

METHODOLOGY

The instructor should prepare a series of short lectures that would indoctrinate the students in the process of OFW and hazards that are present with this process. The instructor should also introduce the tools and equipment that are associated with the process. The instructor should plan to give a demonstration of the OFW process on the first day of the unit. This not only serves as an introduction to the OFW process but also shows the relationships of the various parts of the total system.

Audiovisual presentations can be used to make the students aware of the hazards and the precautions that must be practiced to negate those hazards. Actual safety equipment used by the individual engaged in the OFW process can be introduced by audiovisual methods but the students must be able to see, feel, and wear this equipment before its use will be meaningful.

SUGGESTED INTEREST APPROACHES

1. Have the students generate safety posters concerning the OFW process.

2. Have a tradesman specializing in OFW to be a guest speaker.

3. Create a display representing quality OFW welds.

4. Have the students fuse metals through the OFW process.

UNIT OUTLINE

OXY/FUEL GAS WELDING

(OFW)

I. Introduction

A. Origin

B. Place in industry

C. Economic significance

II. Equipment Nomenclature and Function

A. Cylinders

B. Manifold system

C. Regulators

D. Hoses

E. Check valves

F. Torch butt

G. Torch tip
1. welding
2. heating (rose bud)
3. cutting

III. Safety Hazards Associated with the OFW Process

A. Cylinder hazard

B. Manifold hazard

C. Regulator hazard

D. Hose hazard

E. Check valve hazard

F. Torch butt hazard

G. Tip hazard
   1. welding tip
   2. heating tip (rose bud)
   3. cutting tip

H. Hot slag

I. Hot metal

IV. Consumable Selection

A. Classification

B. Composition

C. Diameter

V. Set Up of Welding System

A. Cylinders

B. Manifold system

C. Regulator

D. Hoses

E. Check valves

F. Torch butt

G. Tip

VI. Welding with the OFW System

A. Prelighting setup

B. Lighting the torch

C. Welding
   1. puddling
   2. butt weld
   3. fillet weld
   4. groove weld

VII. Weld Defects

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. On a written examination, the students will be able to list and describe the advantages and disadvantages of the OFW process, with an accuracy of 75%.

Subject Matter Area	Learning Activities
The OFW Fusion Process	1. Through class presentation, discuss the characteristics of the OFW process, and its advantages and disadvantages. 2. Show students samples of quality OFW welds. 3. Discuss the variables that one must control to obtain a quality OFW weldment. 4. On a written exam, have the students list and discuss the advantages and disadvantages of the OFW process.

2. On a written examination, the students will demonstrate their ability to name and state the function of the OFW equipment, with an accuracy of 75%.

Subject Matter Area	Learning Activities
OFW Equipment	1. Using audiovisuals, chalkboard, and other means, present a lecture on the name and function of the various pieces of OFW equipment.

2. Using the actual OFW equipment, demonstrate the correct operation and use of each component.

3. On a written examination, the students will be able to list the hazards associated with the OFW process and the appropriate procedures and/or equipment necessary to negate those hazards, with an accuracy of 75%.

Subject Matter Area	Learning Activities
OFW Hazards	1. The instructor will present OFW hazards in conjunction with the lessons, at the opportune time.
	2. The instructor should demonstrate safe procedures, making a point to emphasize hazards and the appropriate remediation techniques.
	3. The instructor will make out a safety test dealing with OFW hazards. Students must score 100% on the safety test before they are permitted to work in the welding lab.

4. On a written examination, the students will be able to list and explain the rules pertaining to the storage and use of the various pressurized oxy/fuel cylinders, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Oxy/Fuel Gas Cylinders	1. The instructor will present a lesson on the storage and use of oxy/fuel gas

	cylinders. Safety hazards and safe procedures are to be emphasized.
	6. Have the students form a safety committee with the responsibility of inspecting the oxy/fuel gas cylinders in the lab. The students should submit a written report to the teacher. If any safety violations are discovered, the teacher should take immediate steps to correct them.
	7. On a written quiz concerning oxy/fuel gas cylinders, the students are to score 100% before being allowed to work in the welding lab.
5. On a demonstrative test, the students will demonstrate their ability to correctly assemble an OFW system, with an accuracy of 75%.	
Subject Matter Area	Learning Activities
Assembling OFW Systems	1. Discuss the importance of correctly assembling an OFW system.
	2. Demonstrate the proper procedure of assembling the various components of an OFW system.
	3. Give the students an opportunity to

practice the proper, safe procedure.

6. On a written examination, the students will demonstrate their ability to select the proper tip for a given situation, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Tip Selection	1. Discuss the importance of selecting the proper tip.
	2. Discuss the variables to consider in selecting OFW tips.
	3. Show the students examples of tip selection charts from Victor, Smith, or other manufacturers.

7. On a demonstrative test, the students will demonstrate the correct procedure to turn on gas supplies, correctly set regulators, and to light and adjust the torch to produce a neutral flame, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Lighting the Torch	1. Review the components and the safety rules dealing with the OFW process.
	2. Hand out to each student a copy of the Assembly Sequence and Light-Up Procedure.

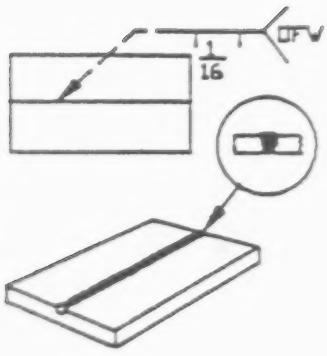
3. Step-by-step, present the correct safe procedure to light the torch, following the steps provided in the Procedure Sheet.

4. Provide the students with lab time to practice.

6. On a demonstrative test, the students will perform a butt weld, a fillet weld on a Tee-joint, and a groove weld utilizing the OFW process to the specified criteria, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Performing OFW Processes	1. Provide the students with samples of OFW processes, pointing out both good and bad points. 2. In detail, describe the safe procedure to perform each of the OFW welds according to the specifications provided in this section. 3. Demonstrate the safe procedure of performing the OFW welds. 4. Have the students practice the OFW welds.

OFW BUTT WELD



Materials:

2pcs. 16ga. x 1 1/2" x 4" hot roll steel

Filler Material:

2ea. AWS RG-45 1/16 dia. mild steel gas welding rod

Flame Adjustment:

Neutral

Procedure:

1. Place coupons on firebrick with a root opening of 1/16".
2. Remove scale and rust with wire brush.
3. Tack weld at both ends of coupon to hold pieces in register.

Note: A tack may be necessary at the mid point of coupon.

4. Using forehand technique, run a single-pass bead.
5. Wire brush, cool, and present welded specimen for inspection by instructor or designated student.

Note: Designated student as welding inspector should be done on a rotational basis giving each student experience in weld inspection.

Inspection:

1. Weld should be distributed in an even, straight line on both coupons.

2. The weld should be uniform in height and width with evenly spaced weld incrementation.

3. Penetration should be complete and uniform as seen from the back side of the weld.

Inspection Check List:

Refer to appendix for OFW butt weld check list.

OFW FILLET WELD
TEE-JOINT

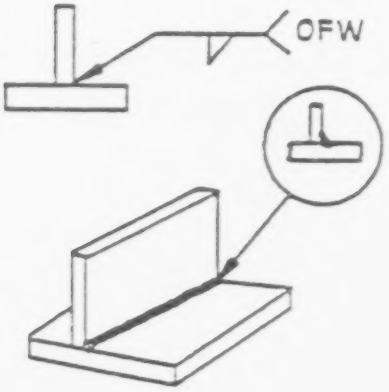
Material:

2pcs. 16ga. x 1 1/2" x 4" hot rolled steel stamped with student roll number on back side

Filler Material:

AWS RE-45 1/16" dia. mild steel

Note: Remove any rust or grease on filler rod before welding. This can be accomplished with abrasive cloth.



Flame Adjustment:

Neutral

Procedure:

1. Position coupons perpendicular to each other on suitable weld surface (fire brick).
2. Place tack weld at the ends of the weld to hold register.

Note: A tack weld in the middle of the weld may be necessary to maintain register and reduce the effect of distortion.

3. Run a single pass fillet weld the length of the coupon, utilizing forehand welding technique.
4. Wire brush, cool, and present welded specimen for inspection.

Inspection Criteria:

1. The bead face should be 45 degrees with respect to parent material.

2. The weld should exhibit good tie-in to parent material without undercut.

3. The weld should exhibit correct width and uniform appearance with even weld incrementation.

4. There should be no burn-through on the back side of the weld.

5. Break or cut and etch the weld to check for correct penetration.

CHECK LIST FOR EVALUATION

Check list should be used to evaluate the student weld. Check list will:

1. Create a uniform and objective method for evaluating student's work.

2. Provide written documentation for grading.

For example: $\frac{\text{Student Weld}}{\text{Possible}} = \frac{35}{40} = 88\%$

UNIT TEST

OXY/FUEL GAS WELDING

(OFW)

PART I

Completion: Based upon your reading and observation in the laboratory, provide the missing word for the sentences below.

1. Acetylene cannot be pressurized in a free state above _____ psi.
2. Acetylene as a fuel gas produces a _____ flame than does MAPP.
3. The size of a gas cylinder is based upon its _____ content.
4. A full oxygen cylinder will contain about _____ psi of pressure.
5. Acetone is present in a/an _____ cylinder.
6. A full acetylene cylinder contains approximately _____ psi.
7. During welding, the acetylene cylinder should be opened only _____ of a turn.
8. During welding the oxygen cylinder should be opened _____ way.
9. A number _____ lens is used for OFW.

PART II

Matching: Select the lettered item in the second column that best describes or explains the numbered item in the first column.

_____ 1.	RG 45, RG 65	A. alternate fuel gas
_____ 2.	open 3/4 of a turn	B. prevent flashback C. AWS Classification for filler rods
_____ 3.	tip cleaner	D. acetylene valve E. used to clean tip orifice
_____ 4.	check valve	F. fuel gas distribution system
_____ 5.	MAPP	G. used to light torches H. never used on any regulator
_____ 6.	open all the way	I. oxygen valve J. displays cylinder and working pressure
_____ 7.	manifold system	
_____ 8.	friction torch lighter	
_____ 9.	oil	
_____ 10.	regulator gauges	

UNIT TEST

ANSWER KEY

OXY/FUEL GAS WELDING

(OFW)

PART I: Completion

1. 15
2. hotter
3. cubic
4. 2300
5. acetylene
6. 330
7. 3/4
8. completely or all the way
9. 5

PART II: Matching

1. C
2. D
3. E
4. B
5. A
6. I
7. F
8. G
9. H
10. J

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit test.
2. Quizzes.
3. Project grades.
4. Safety poster grades.

EQUIPMENT AND SUPPLIES

Student	Teacher
Pencil	Chalkboard, chalk, eraser
Notebook	Lesson plan
Textbook	Textbook
Safety glasses	Teacher's guide
Safe welding attire	Curriculum guide
	Audiovisual materials
	OFW equipment & supplies
	Safety glasses

BULLETIN BOARD IDEAS

1. Display posters from various OFW manufacturers.
2. Display student-generated safety posters.
3. Post safety rules for OFW process.
4. Post OFW student assignments.

Material: _____

Consumable: _____

Machine Setting: _____

OFW Fillet Weld T-Joint Check List

Date: _____

Instructor: _____

Period: _____

Student Names	Inspection Criteria: Weld Selection and Set-up	Correct Rod Selection and Rod positioning	Uniform Bead Width	Uniform Crown w/o undercut	Correct Tie-in	Correct coupons	Uniform Weld Incrementation	Correct Weld penetration	Score	Remarks

Material: _____

Consumable: _____

Machine Setting: _____

OFW Butt Welds Check List

Date: _____

Instructor: _____

Period: _____

Inspection Criteria

Student Names	Equip Selection and Set-up	Root Opening	Tack	Bead edges parallel to root opening	Weld Width	Crown Height	Weld incrementation	Penetration complete and uniform	Score	Remarks

Oxyfuel Gas Setup and Lighting Check List

Date: _____

Instructor: _____

Period: _____

Student Names

	Assembly Procedure											Light Up Procedure										
	Inspect Tank, Manifold	Remove Cap	Check Threads	Crack Valve	Attach Regulator	Back-Out Reg. Screw	Open Valve	Purge Regulator	Attach Hose	Purge Hose	Attach Torch Butt	Purge Torch Tip	Charge System	Correct Reg. Setting	Purge Torch	Crack Torch Fuel Valve	Light Torch	Adjust for Neutral Flame	Adjust for Carburizing	Shut Off Torch	Shut Down System	Bleed System Down	Replace Equipment	TOTAL

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UNIT V

OXYGEN FUEL GAS CUTTING

(OFC)

INTRODUCTION

Most ferrous metals can be efficiently cut using the oxygen fuel gas cutting process. This process produces extremely high temperatures through the combustion of a fuel gas in the presence of commercially pure oxygen. The oxyacetylene flame, for example, is capable of producing temperatures in excess of 6,000 degrees Fahrenheit. When ferrous metals are heated to such temperatures and oxygen is injected directly into the molten puddle, the resulting rapid oxidation causes the metal to be vaporized. Thus the metals are "cut".

Technology has had a positive effect on the OFC process. Today's OFC systems not only cut more intricate shapes in higher numbers, but also produce a quality cut. Current processes utilize track torches, templet trace torches, optic trace torches, and computer controlled torches (CNC).

To be successful in the welding laboratory, students must be capable of performing the OFC process according to specified criteria. This unit is designed to ensure that success.

COMPETENCIES

1. Explain and compare the various OFC processes in terms of their advantages and disadvantages.
2. Identify the safety hazards associated with the OFC processes.
3. Identify the components of and make the necessary adjustments to OFC equipment.
4. Perform the OFC process according to specified criteria.
5. Identify common defects associated with the OFC process.

GENERAL PERFORMANCE OBJECTIVES/GOALS

1. Develop an understanding of the various OFC processes.

2. Comprehend and be able to neutralize the hazards associated with the OFC process.

3. Identify and describe the purpose and function of the OFC equipment and supplies.

4. Adjust and operate common OFC equipment.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will match the specific hazards found in the OFC process with the correct personal protective equipment and/or procedure needed to neutralize that hazard, with an accuracy of 100%.

2. On a written examination, the students will be able to state the function and rationale of the OFC process, with an accuracy of 75%.

3. On a written examination, the students will be able to identify and state the advantages of the various gases utilized with the OFC process, with an accuracy of 75%.

4. On a written examination, the students will be able to identify how changes in the cutting variables will affect the quality of the cut, with an accuracy of 75%.

5. On a demonstrative examination, the students will be able to perform oxygen fuel gas cutting according to written specifications, with an accuracy of 75%.

6. On a written examination, the students will be able to recognize and state the probable cause of defects associated with the OFC process, with 75% accuracy.

7. On a written examination, the students will demonstrate their knowledge of mechanically driven OFC systems, with an accuracy rate of 75%.

METHODOLOGY

This unit on OFC will entail the use of class lecture, class and individual demonstrations, and student work on graded exercises. The instructor can incorporate a wide variety of exercises that includes manual straight line, curve, and pierce cutting along with automated cutting, utilizing any automated means available. It is suggested that coupons needed for other areas of this welding course can be generated as practice of the OFC process.

SUGGESTED INTEREST APPROACH

1. Have an expert in the area of flame cutting demonstrate precision hand cutting.

2. Contact the sales representative for OFC equipment to give a safety presentation and equipment demonstration of their OFC equipment.

3. Have students generate safety posters dealing with the elements of the OFC process.

UNIT OUTLINE

OXYGEN FUEL GAS CUTTING

(OFC)

I. Introduction

A. Origin

B. Place in industry

C. Economic significance

D. Future of the OFC process

E. Safety associated with the OFC process

II. Equipment Nomenclature and Function

A. Cylinders/manifold system
1. regulators
2. hoses
3. check valves
4. torch butt
5. cutting attachment
6. cutting tips
7. automatic movement systems
a) track torch
b) templet trace
c) optic trace
d) CNC

B. Consumable gases
1. oxygen
2. acetylene
3. MAPP

III. Cutting with the OFC Process

A. System assembly

B. Parameter setting

C. Tip selection

D. Purge

E. Light up

F. Cutting
   1. straight cut (hand)
   2. curved cut (hand)
   3. pierce cut (hand)
   4. straight cut (machine)
   5. curved cut (machine)

IV. Inspection Criteria

A. Cut lines
   1. straight
   2. kerf

B. No melting (top edge)

C. Vertical drag lines

D. Little slag at bottom

E. Tolerance ($\pm$ 1/16")

SPECIFIC PERFORMANCE OBJECTIVES
AND LEARNING ACTIVITIES

1. On a written examination, the students will match the specific hazards found in the OFC process with the correct personal protective equipment and/or procedure needed to neutralize that hazard, with an accuracy of 100%.

Subject Matter Area	Learning Activities
OFC Hazards	1. Have a local representative of an OFC equipment manufacturer serve as a guest speaker to discuss OFC safety, hazards, and personal protective equipment.
	2. Discuss with the students the unique hazards of OFC regarding explosive gases and hazardous equipment.
	3. Discuss fire safety including the classes and operation of fire extinguishers which the students may have to use during the course.
	4. Discuss the use of appropriate personal equipment when performing the OFC process.
	5. Discuss emergency procedures in case of an accident involving OFC equipment.
	6. Require the students to exhibit safe behavior in all work with OFC equipment.

2. On a written examination, the students will be able to state the function and rationale of the OFC process, with an accuracy of 75%.

Subject Matter Area	Learning Activities
The OFC Process	1. With audiovisual presentation and lecture, discuss the various types of machines and equipment used in the OFC process. 2. Discuss the economic significance of the various OFC processes.

3. On a written examination, the students will be able to identify and state the advantages of the various gases utilized with the OFC process, with an accuracy of 75%.

Subject Matter Area	Learning Activities
OFC Gases	1. Present a lecture on the many different gases used in the OFC process. 2. Compare the OFC gases in terms of their advantages and disadvantages. 3. Demonstrate to the students the flames created by the various types of gases. 4. Have the students practice hand cutting with different types of gases.

4. On a written examination, the students will be able to identify how changes in the cutting variables will affect the quality of the cut, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Cutting Variables	1. Discuss with the students the various machine controls which can be varied. 2. Explain the limits of variability of each machine control. 3. Explain to the students how making several adjustments simultaneously affects the cutting process. 4. In the lab, demonstrate the selection and control of the variables. 5. Have the students practice varying the OFC controls while noting the resulting changes in cutting precision, speed, and quality.

5. On a demonstrative examination, the students will be able to perform oxygen fuel gas cutting according to written specifications, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Oxygen Fuel Gas Cutting	1. Present a demonstration of the OFC process. 2. Cite examples where the OFC process is used.

3. Exhibit samples of good and poor OFC cutting.

4. Lead students through component selection, adjustment, and light up procedures.

5. Discuss the burn characteristics of alternate fuel gas as related to the gas being used in the laboratory.

6. Demonstrate the following: straight line, bevel, and pierce cut.

STRAIGHT LINE, BEVEL, AND PIERCE CUT

Material:

1pc. 1/2" x 4" x 4" steel plate
1pc. 1/8" x 1-1/2" x 1-1/2" x 18" angle iron mild steel

Consumables:

Acetylene

Procedure:

1. With soap stone lay out parallel lines 3/4" back from parallel edges.

2. With diagonal method, locate center of workpiece.

3. With dividers and soap stone, inscribe

a 2" dia. circle with its center in the center of the work piece.

4. Select the correct components and make a square cut on one of the lines parallel to the edge.

5. Using the angle iron as a straight edge, make a 45 degree bevel cut on the other edge.

6. Cut the 2" hole in the center of the work piece.

Inspection Criteria:

1. Cut lines should be straight.

2. The parent metal cut should be clean and free from excessive slag.

3. The top edge should not be rounded.

4. Drag lines should be vertical.

Note: Similar exercises can be performed using guide rollers for straight cuts and the circle cutting attachments.

6. On a written examination, the students will be able to recognize and state the probable cause of defects associated with the OFC process, with 75% accuracy.

Subject Matter Area	Learning Activities
OFC Defects	1. Discuss with the students the major causes of OFC defects. 2. Provide the students with samples of the defects. 3. In the lab, demonstrate to the students how defects occur.

7. On a written examination, the students will demonstrate their knowledge of mechanically driven OFC systems, with an accuracy rate of 75%.

Subject Matter Area	Learning Activities
Mechanically Driven OFC Systems	1. Present a lecture on the uses of mechanically driven OFC systems. 2. Discuss the advantages of mechanically driven OFC systems in industry. 3. Discuss the operation of the common mechanically driven OFC systems. 4. With the available equipment, demonstrate the operation of mechanically driven OFC systems. 5. Permit the students to practice using the mechanically driven OFC systems in the lab.

UNIT TEST

OXYGEN FUEL GAS CUTTING

True or False

_____ 1. The tip used for OFC is the same as the tip used for OAW.

_____ 2. The regulator used for acetylene can also be used for MAPP gas.

_____ 3. The pre-heat flame adjustment is also called the oxygen lever.

_____ 4. Nonvertical drag lines on an OFC cut surface indicate that the cut was made at the correct speed.

_____ 5. Excessive slag on the bottom of the cut indicates the cutting speed was too slow.

_____ 6. The kerf closes in and fuses. This could be an indication of the cutting tip being much too large.

_____ 7. Torch backfires can be caused by a dirty or defective tip.

_____ 8. Acetylene is the hottest burning fuel gas.

_____ 9. Melted over top edges of an OFC cut is an indication of having a tip that is too small.

_____ 10. Oxygen and acetylene should have the same pressure on the regulator when cutting.

Matching: Match the equipment with the correct use, specification, or function.

_____ 11. Tip size

_____ 12. Regulators

_____ 13. Hoses

_____ 14. Smaller holes in tip

_____ 15. Oxygen valve on the torch butt

_____ 16. Oxygen lever on the cutting attachment

A. Controls volume of gases to the torch

B. Controls amount of pre-heat flame

C. Transports gases from regulators to torch

D. Use for preheat flame

E. Activates cutting oxygen

F. Opened all the way

List A for advantage and B for disadvantage of OFC as a process compared to mechanical operations such as sawing.

_____ 17. Speed

_____ 18. Heat affected zone

_____ 19. Complexity of operation

_____ 20. Cost of equipment

_____ 21. Cost of operation

_____ 22. Versatility of cut

UNIT TEST

OXYGEN FUEL GAS CUTTING

ANSWER KEY

True or False:

1. F
2. T
3. F
4. F
5. T
6. T
7. T
8. T
9. F
10. F

Matching:

11. B
12. A
13. C
14. D
15. F
16. E

List:

17. A
18. B
19. B
20. A
21. A
22. A

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit exam.
2. Quizzes.
3. Student projects.
4. Safety posters.
5. Student reports/presentations.

EQUIPMENT AND SUPPLIES

Student

Pencil
Notebook
Textbook
Safety glasses
Safe clothing

Teacher

Chalkboard, chalk, eraser
Audiovisual equipment
Textbook
Lesson plan
Curriculum guide
Safety glasses
OFC equipment

BULLETIN BOARD IDEAS

1. Post safety rules for OFC.
2. Display product literature from various manufacturers.
3. Display student safety posters.
4. Post clean-up rules and assignments for OFC.

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UNIT VI

SHIELDED METAL ARC WELDING

(SMAW)

INTRODUCTION

Arc welding is the most frequently used fusion process, because of its versatility. The versatility of this process is due to the wide range of consumables available. The arc process with the proper selection of machines and consumable can weld most materials found in industry.

SMAW is a coalesence process using an electric arc as a heat source and the consumable, current carrying, electrode as a source of filler material. The electrode arc is generated between the tip of the electrode and the parent metal. Heat from the arc melts the parent metal and the filler metal causing the two metals to flow together. When the filler metal is melted, it also ignites a coating on the outer surface producing a shielding gas which helps to reduce atmospheric contamination to the weld.

COMPETENCIES

1. Develop an understanding of the Shielded Metal Arc Welding process (SMAW).

2. Identification of the equipment and consumables used for the SMAW process.

3. Condition, use and types of current available with the SMAW process.

4. Identification of electrodes, their reliability, classification system, use, and physical and electrical properties.

5. Equipment needed for the SMAW process.

6. The welding process, strike arcs, weave beads, butt welds, fillet welds, positioning and special applications.

7. Recognition and alleviation of defects associated with the SMAW process.

GENERAL PERFORMANCE OBJECTIVES/GOALS

1. Comprehend and be able to neutralize the hazards associated with the SMAW process.

2. Develop an understanding of the electric arc welding process.

3. Be able to identify the components of a SMAW system and explain the components in terms of their function.

4. Develop an understanding of the consumables used in the SMAW process.

5. Relate power supply settings to the desired results of the SMAW process.

6. Be able to accomplish the SMAW process.

7. Be able to recognize and evaluate causes of common effects associated with the SMAW process.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will be able to match the specific hazard found in the SMAW process with the correct personal protective equipment and/or procedure needed to neutralize that hazard, with an accuracy of 100%.

2. On a written examination, the students will be able to state the function and rationale of the SMAW process, with an accuracy of 75%.

3. On a written examination, the students will demonstrate their understanding of the consumables used in the SMAW process by correctly stating the rationale for each number and letter of the AWS Classification System, and the use of the classification system found in the SMAW process, with an accuracy of 75%.

4. On a written examination, the students will be able to predict how a change in the power supply setting and welding variables will affect the welded product, with an accuracy of 75%.

5. The students will demonstrate their ability to accomplish SMAW, in accordance with the stated criteria, with an accuracy of 75%.

6. On a written examination, the students will be able to recognize and state the probable cause of defects associated with the welding process, with an accuracy of 75%.

METHODOLOGY

This unit on SMAW will entail the use of class lectures, class and individual demonstrations, and student work on graded projects. As SMAW is the most predominant welding process in Louisiana, a greater portion of the semester will be devoted to teaching/learning experiences in this area. The instructor should incorporate a wide variety of student exercises reflective of the many types of SMAW welds, and not just settle for the more basic. The instructor should vary the thickness of metal used, the diameter and type of electrode, position, and type of weld.

SUGGESTED INTEREST APPROACHES

1. Take the students on a walking tour of the school campus and point out the places where the structure steel has been welded.

2. Have the students generate safety posters dealing with SMAW.

3. Have a certified welder address the class on the diversity of the SMAW process.

UNIT OUTLINE

SHIELDED METAL ARC WELDING

I. Introduction

A. Origin

B. Place in industry

C. Economic significance

D. Future of SMAW

E. Safety associated with the SMAW process

II. Equipment Nomenclature and Function

A. Power supplies
1. transformer
2. transformer/rectifier
3. motor driven

B. Consumables
1. AWS classification
2. function classification
a) fast freeze
b) fast fill
c) fill freeze
d) low hydrogen
3. diameter criteria

III. Welding with SMAW System

A. Arc strike exercise

B. Stringer bead exercise

C. Stringer bead exercise with various electrodes

D. Weave bead exercise

E. Butt weld (V-groove open root) flat position (1G)

F. Fillet weld horizontal position (2F)

G. Stringer bead horizontal position

H. Butt weld (single V-groove open root) horizontal (2G) position

I. Stringer bead vertical uphand position

J. Weave bead vertical uphand position

IV. Inspection Criteria

A. Check list

B. Etched specimens

Note:

1. Welding by students should be accomplished on clean AISI 1018 - 1020 steel 1/4" x 6" x 6" utilizing fresh E 6013 for all initial and flat welding.

2. The students should have access to and be familiar with at least one electrode from the following groups: Fast Fill, Fill Freeze, Fast Freeze, and Low Hydrogen.

3. Depending on the circumstances of the school and laboratory funding, metal for the 6" x 6" welding coupons should be purchased as such, or scrap can be used provided it is clean. Clean metal will give the students faster, more successful results.

4. The electrode utilized for the first exercises should be of the E 6013 class. It is recommended that the Lincoln Fleetweld 37 be used because it is very easy starting, tolerates a variable arc length, and will give excellent results very early in the students' welding experiences regardless of the students' skills. This is also an excellent electrode to start vertical down welding because it gives such clean results with a variety of current settings.

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. On a written examination, the students will be able to match the specific hazard found in the SMAW process with the correct personal protective - equipment and/or procedure needed to neutralize that hazard, with an accuracy of 100%.

Subject Matter Area	Learning Activity
SMAW Safety	1. With audiovisual presentations, demonstrations and lectures, present the hazards associated with the SMAW process, and how their potential can be neutralized and/or reduced.
	2. Use of safety posters generated by welding equipment manufacturers.

2. On a written examination, the students will be able to state the function and rationale of the SMAW process, with an accuracy of 75%.

Subject Matter Area	Learning Activity
Shielded Metal Arc Welding Process (SMAW)	1. Using overhead transparencies, audiovisual material and chalk board demonstrations, the instructor will present the overall concept of the SMAW system, identifying the components and demonstrating the function of each component.

3. On a written examination, the students will demonstrate their understanding of the consumables used in the SMAW process by correctly stating the rationale for each number and letter of the AWS Classification System, and the use of the classification system found in the SMAW process, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Welding Consumables	1. With overhead transparencies, the instructor will demonstrate the derivation and meaning of each alpha-numeric character of the AWS Classification System in terms of tensile strength, position, current setting, and application.
	2. Pass around to the students the various electrodes they will use in the lab. Call their attention to the unique classification number and markings on each rod.

4. On a written examination, the students will be able to predict how a change in the power supply setting and welding variables will affect the welded product, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Welding Variables	1. Lecture on the common welding machine controls that a welder must learn to adjust.
	2. Demonstrate to the class how to identify the controls and how

to make the necessary adjustments.

3. Make several welds before the students. Adjust the machine controls to obtain both good and poor welds.

4. Let the students alter one of the conditions and accomplish the weld. Compare the results with the control piece and interpret how the changes in the variables can affect the outcome of the welded product. This can be done with amperage, voltage (arc length), travel, and angle of the electrode.

5. The students will demonstrate their ability to accomplish SMAW, in accordance with the stated criteria, with an accuracy of 75%.

Subject Matter Area	Learning Activity
The SMAW Process	1. After viewing demonstrations and participating in supervised practice, the students will be able to execute these procedures: a. Select the proper equipment for the SMAW process. b. Select and put on proper safety equipment needed for the SMAW process.

c. Preset equipment for welding.

d. Select electrodes by size and classification.

e. Accomplish the following procedures:
   1) arc strike
      a) tap
      b) drag
   2) drag bead
   3) weave bead
   4) butt weld using
      a) square
      b) leveled
      c) chamfered
      d) with and without a backing strip
   5) fillet weld
   6) horizontal position
   7) vertical position
   8) overhead
   9) cast iron welding
   10) pipe welding

6. On a written examination, the students will be able to recognize and state the probable cause of defects associated with the welding process, with an accuracy of 75%.

Subject Matter Area	Learning Activities
Weld Defects	1. Using audiovisual presentations and actual welded specimens, identify the following common weld defects that are indigenous to the welding process. The

defects identified should include but not be limited to the following:

Excessive splatter
Poor bead appearance
Poor fusion
Poor penetration
Slag inclusion
Porosity
Cracking
Undercutting

2. After the students have produced a weld free from defect, have the students change one parameter of the weld until a defect occurs, leaving all other parameters unchanged.

3. Utilizing a coupon that has a good weld and a weld with an obvious weld defect beside the good weld, cut with a hack saw through the coupon exposing a cross section of both welds side by side. Polish the cross section with a 180 grit abrasive and etch with a macroetching solution. Then compare all aspects of the defect.

Note: Caution should be used when working with etching solutions. Eye protection and face shield should be worn at all times. Etching should always be accomplished in a well-ventilated area, keeping students out of the path of fumes. Handling of etching solutions should always be done wearing plastic gloves.

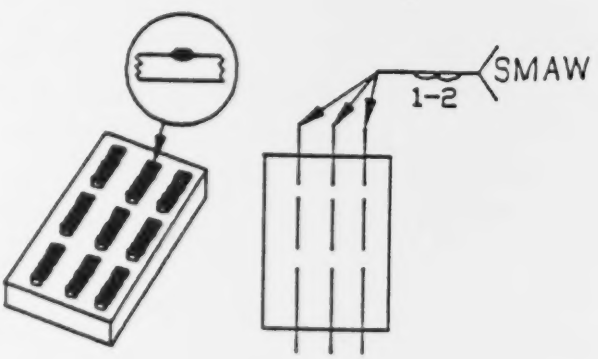
4. Point out common weld defects associated with the SMAW process.

5. Analyze and rectify the cause of common SMAW defect.

The students will be able to accomplish the following exercises and welds according to the established criteria with an accuracy of at least 75%.

1. Arc Strike (exercise)
2. Stringer Beads (exercise)
3. Stringer Bead (5 classes of electrodes)
4. Weave Beads
5. Butt Weld (single V-groove open root) flat position
6. Fillet weld horizontal (2g position)
7. Stringer bead horizontal position
8. Butt weld (single V-groove open root, horizontal (2g position))
9. Stringer bead vertical up-hand position
10. Vertical weave up-hand position

EXERCISE
ARC STRIKE



Striking the Arc

Materials:

1pc. 1/4" x 4" x 4" mild steel plate or hot roll

Consumables:

5 ea., E6013 1/8" dia. electrodes

Machine Setting:

AC, 125 amps

Material Preparation:

Remove any loose scale or rust with a wire brush or suitable abrasive.

Note: Wear suitable eye protection.

Technique:

1. Wearing gloves and other safety equipment, place an electrode in the holder.
2. Establish proper electrode angle (approximately 76 degrees in the direction of the travel).
3. Have students assume as comfortable a position as possible and still maintain correct electrode angle in relation to coupon.
4. Position electrode over work.
5. Turn on machine.
6. Cover eyes with welding shield (No. 9 or 10 lens).
7. With scratching technique let students establish arc.

Note: Amperage setting should be 125-130 amps for starting on cold material, using a collet electrode. Turn down amps as work warms up. Material should be tacked or secured while performing weld.

8. Let arc burn for a count of 5. Remember to feed electrode into the puddles as it gets shorter.

9. Extinguish arc.

10. Remove slag.

Note: With correct welding parameters in place, the flux should peel off the weld without hard chipping or vigorous wire brushing.

11. Continue with arc strike with 5 second burn at all points of line intersection on the coupon.

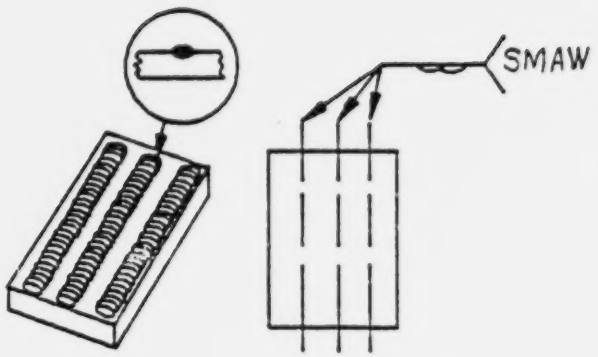
12. Remove slag by chipping or wire brush.

Note: Caution students to brush and chip slag away from their body.

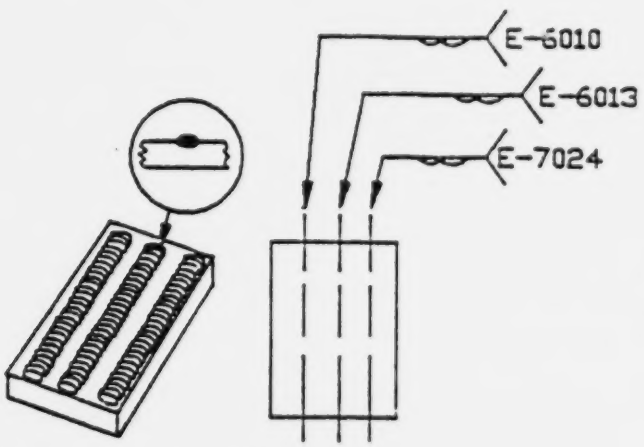
13. After securing permission by instructor using the same setting and electrode, connect the points of intersection using drag or stringer bead technique. Extinguish arc. Remove slag, cool work piece, and present to instructor for evaluation.

APPLICATION
STRINGER BEADS

On the reverse side of the arc strike coupon, the students will weld a series of stringer beads in accordance with established inspection criteria.



Stringer Beads



Stringer Beads with Various Electrodes

Material:

1/2" x 4" x 4" mild steel plate or hot roll

Electrodes:

5ea. E-6013 electrodes

Procedure:

1. Remove rust and mill slag with an abrasive or wire brush. If rust removal is to be accomplished on a motor-driven wire wheel, gloves should <u>not</u> be worn. Also the coupon could be increased in length to give the students something to hold on to while removing rust or slag.
2. Lay out coupon with soap stone, at 3/4" increments along the length of the work piece.

Welding Technique:

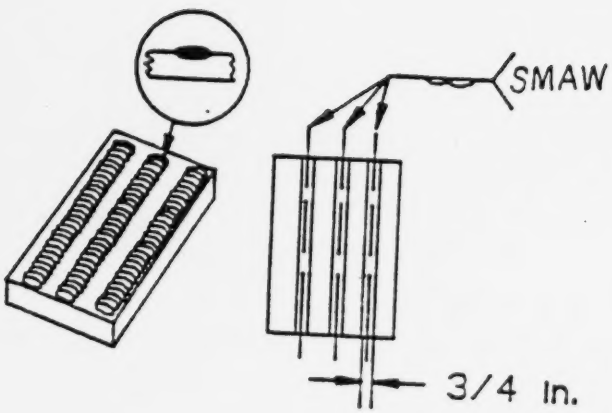
1. Place the coupon on a grounded surface.
2. Weld with stringer beads along the soap stone lines.

3. Between the stringer beads, weld (weave) beads.

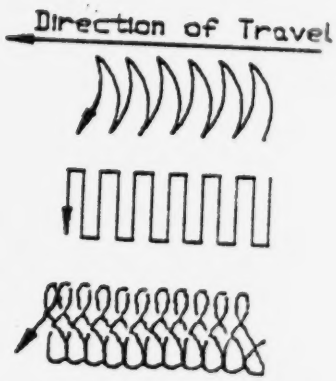
4. Experiment with different types of weave patterns.

5. As the work piece heats up, reduce the amperage.

APPLICATION
WEAVE PATTERN



Weave Beads



Weave Bead Patterns

Material:

1/4" x 4" x 10" plate or hot roll

Consumables:

5ea. E-6013 1/8" diameter

Preparation:

1. Remove any rust or loose mill scale with abrasive or wire brush.

2. Lay out with soapstone at 3/4 increments parallel to the long edge or the coupon.

Technique:

1. Weld a weave bead pattern along each soapstone line.

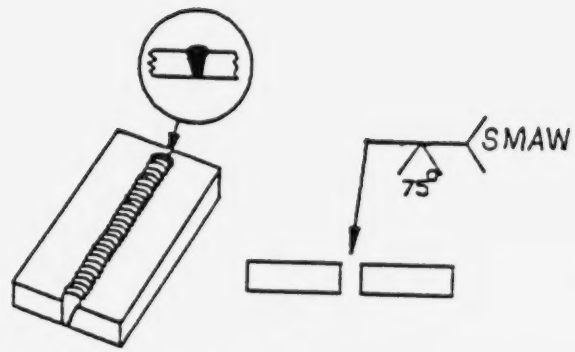
2. Use weave patterns demonstrated.

3. Use hot and cold machine settings while working with

each pattern; note weld difference.

4. Try to establish uniform electrode movement.

APPLICATION
BUTT WELD (SIMPLE GROOVE OPEN ROOT)
FLAT (1G) POSITION



Butt Weld (Single V-Groove Open Root)
Flat (1G) Position

Material:

2pcs. 3/8" x 4" x 6" hot roll or steel plate

Bevel on edge of each coupon to 75 degrees.

Consumables:

1/8" dia. E-6010 or
1/8" dia. E-6011

Machine Settings:

E-6010 use DCRP 100 Amps
E-6011 use AC 100 Amps

Procedures:

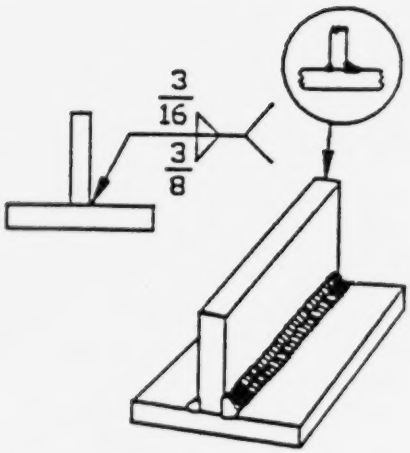
1. Remove rust and loose scale.

2. Tack weld to maintain proper root register.

3. Weld root pass, chip and brush weld.

4. Weld filler passes; chip and brush weld between each pass. Increase amperage on filler passes to insure good tie-in.

FILLET WELD
HORIZONTAL (2F) POSITION



Fillet Weld
Horizontal (2F) Position

Material:

2pcs. 1/4" x 2" x 6" hot roll or plate

Consumables:

E-6013 1/8" dia. electrodes

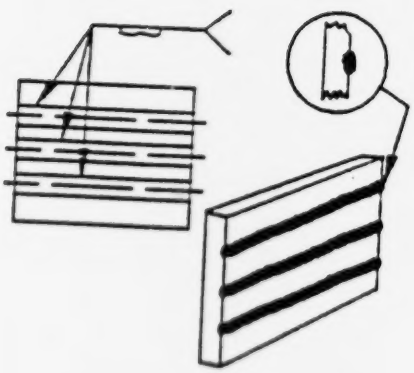
Machine Settings:

120-125 Amps AC or DCSP

Procedure:

1. Remove rust and loose scale.
2. Tack weld coupon at a 90-degree angle.
3. Weld both sides of specimen with hot stringer beads.
4. Weld one side of weld with two additional stringer beads.
5. Chip, cool, and present for inspection.
6. Cut and address specimen with 180 grit abrasive.
7. Etch.

STRINGER BEAD
HORIZONTAL POSITION



Stringer Beads
Horizontal Position

Material:

1/4" x 6" x 8" mild steel plate

Consumables:

E6010 or E6011

Machine Settings:

1/8" dia. E6010 95 Amps DCRP
1/8" dia. E6011 95 Amps AC

Procedure:

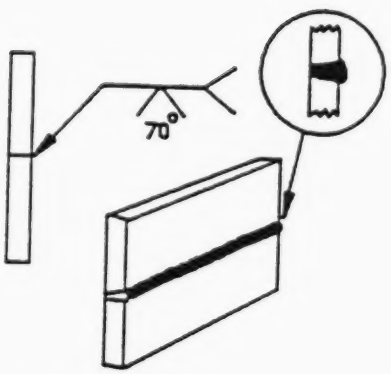
1. Remove rust and loose scale.
2. Lay out at 3/4" increments from the long edge with soapstone.
3. Tack weld specimen in the horizontal position.
4. Starting at centerline, run a bead half the length of the coupon and break the arc.
5. Weld similar beads on the remaining guide lines on the first half.
6. Brush chip weld.
7. Repeat exercise on the second half of coupon and fill craters.

8. Cut coupon in half; abrade exposed welds with 180 grit abrasive.

9. Etch.

10. Present for inspection.

BUTT WELD (SINGLE V-GROOVE OPEN ROOT) HORIZONTAL (2G) POSITION



Butt Weld (Single V-Groove Open Root) Horizontal (2G) Position

Material:

2pcs. 3/8" x 4" x 8" hot roll or mild steel plate

Consumables:

1/8" dia. E 6010 or
1/8" dia. E 6011

Machine Settings:

E 6010 DCRP 95-110 Amps
E 6011 AC 95-110 Amps

Procedure:

1. Remove rust and loose scale.

2. Establish 70-degree bevel at edges to be joined.

3. Tack weld specimen in flat position to maintain minimum root opening.

4. Weld root pass.

5. Weld remaining filler passes at increased amperage to insure good tie-in.

6. Chip, wire-brush, and cool.

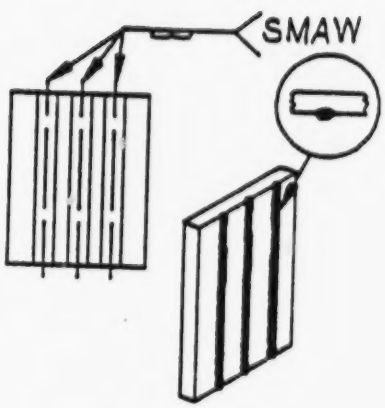
7. Cut specimen across weld.

8. Remove tool marks on the cut surface.

9. Etch.

10. Present welded specimen for inspection.

STRINGER BEADS
VERTICAL UPHAND POSITION



Stringer Beads
Vertical Up Position

Material:

3/8" x 4" x 10" hot roll or mild steel plate

Consumables:

1/8" diameter E 6010 or
1/8" diameter E 6011

Machine Settings:

E 6010 DCRP 90-100 Amps
E 6011 AC or DCRP 90-100 Amps

Procedure:

1. Remove rust and loose scale.

2. Lay out coupon with soapstone on 3/4" increments parallel to the long edge.

3. Secure coupon in the vertical position to be welded.

4. Run stringer bead uphand along the soapstoned lines to approximately mid-way up the coupon.

5. Restart arc and weld remaining half of coupon.

6. Fill crater at the end of each bead.

7. Remove specimen from welding position.

8. Remove all slag.

9. Cut across weld.

10. Remove tool marks with 180 grit abrasive.

11. Etch and clean up.

12. Present for inspection.

UNIT TEST

SHIELDED METAL ARC WELDING

PART I. Multiple Choice:

_____ 1. SMAW is the acronym for:
a. MIG welding
b. stick welding
c. TIG welding
d. friction welding

_____ 2. The output of a transformer type welding machine is:
a. AC
b. DC
c. DC+
d. DC-

_____ 3. The welding machine that has the lowest basic price is:
a. transformer type
b. transformer-rectifier
c. generator

_____ 4. The welding current that has the most efficient arc is:
a. AC
b. AC-
c. DC+
d. DC-

_____ 5. The welding current that is the best choice for welding out of position is:
a. AC
b. AC-
c. DC-
d. DC+

_____ 6. The welding current that produces the smoothest, less penetrating arc at any given amperage setting is:
a. AC
b. ACSP
c. DCRP
d. DCSP

_____ 7. 6010 and 6011 electrodes are classified as _____ electrodes.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 8. 6027 and 7024 electrodes are classified as _____ electrodes.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 9. 6012, 6013, and 7014 electrodes are classified as _____ electrodes.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 10. 7018 and 11018 electrodes are classified as _____ electrodes.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 11. Out of position welding is best accomplished with a _____ electrode.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 12. The electrode that is used to weld problem steel comes from the _____ group.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 13. The electrode that is used to weld poor fit up joint comes from the _____ group.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 14. The electrode that is used for high-speed, flat position welding of tight fitting joint comes from the _____ group.
a. fast freeze
b. fast fill
c. fill freeze
d. low hydrogen

_____ 15. Electrodes that have "0" and "5" as last digits in their AWS classification are burned with _____ current selection.
a. AC
b. DC+
c. AC-
d. DC-

_____ 16. Electrodes having "1", "6", and "8" as the last digits in their AWS classification require a/an _____ current setting.
a. AC
b. AC-
c. DCSP
d. DCRP or AC

_____ 17. Electrodes with the last digit in their AWS classification a 2 and 7 must be used with _____ current setting.
a. AC
b. AC+
c. DCRP
d. DCSP or AC

_____ 18. A 1/8" diameter electrode should have an approximate current setting of:
a. 125 amps
b. 200 amps
c. 250 amps
d. 45 amps

_____ 19. In a reverse polarity circuit, the electrode is:
a. not connected
b. negative
c. connected
d. positive

_____ 20. A slag that forms on the weld bead:
a. serves no real purpose
b. prevents rusting
c. insulates the cooling weld
d. becomes part of the weld

_____ 21. The third digit in the AWS classification code indicates:
a. welding position
b. current requirements
c. amount of penetration
d. type of flux coating

_____ 22. A transformer type power supply produces:
a. AC and DC current
b. DC only
c. AC only
d. DC straight but not reverse

_____ 23. A rectifier type power supply changes:
a. AC to DC current
b. straight to reverse polarity
c. high to low voltage
d. low voltage to high

_____ 24. EXW is used for making:
a. U.S. coinage
b. machine parts
c. pipe
d. sheeting for aircraft

PART II. <u>True/False</u>:

_____ 25. A welded joint may show no signs of distortion but may be high in stress.

_____ 26. Angular distortion can best be viewed in a lap joint.

_____ 27. There is no stock removal in preparing a "T" joint for a butt weld.

_____ 28. The heat generated by welding will generally increase the yield point of the parent material.

_____ 29. Two plates being butt welded together that are free to move are drawn together with a distortion called longitudinal contraction.

_____ 30. If a weld is deposited lengthwise along a strip of steel which is free to move, the resulting upward bow is due to transverse contraction.

_____ 31. The effect of transverse contraction can be reduced by a tack weld being placed along the seam to be welded.

_____ 32. Transverse shrinkage is less for a lap joint than for a V-butt joint.

_____ 33. It is possible to have a butt weld on a butt joint.

_____ 34. Wandering or backstepping offsets the effect of certain types of distortion.

UNIT TEST

ANSWER KEY

SHIELDED METAL ARC WELDING

Multiple Choice:

1. B
2. A
3. A
4. A
5. D
6. D
7. A
8. B
9. C
10. D
11. A
12. D
13. A
14. B
15. B
16. D
17. D
18. A
19. D
20. C
21. A
22. C
23. A
24. A

True/False:

25. T
26. F
27. F
28. T
29. F
30. F
31. T
32. F
33. T
34. T

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit test.
2. Quizzes.
3. Student project grades.
4. Safety poster grades.

EQUIPMENT AND SUPPLIES

Student	Teacher
Pencil	Chalkboard, chalk, eraser
Notebook	Lesson plan
Textbook	Textbook
Safety glasses	Teacher's guide
Safe welding attire	Audiovisual materials
	SMAW equipment and supplies

BULLETIN BOARD IDEAS

1. Display literature from various SMAW manufacturers.
2. Display student generated SMAW safety posters.
3. Post the safety rules for SMAW.
4. Post SMAW students' assignments.

Material: _____

Consumable: _____

Machine Setting: _____

SMAW Stringer Bead Check List

Date: _____

Instructor: _____

Period: _____

Student Names	Inspection Criteria										Remarks
	Location of weld	Straightness of weld	Correct weld speed	Uniformity of sides and ripples	Penetration of weld stock	Re-in to parent	Correct crown	No undercut	No porosity	Correct bead width	Score	

Material: _____

Consumable: _____

Machine Setting: _____

Date: _____

Instructor: _____

Period: _____

SMAW Weave Pattern Check List

Inspection Criteria

Student Names

Prep of coupon

Machine Setting

Weave motion

Electrode into puddle

Arc length

Movement of bead

Height and width

Bead uniformity

Restart and arc termination

Score

Remarks

Material: _____

Consumable: _____

Machine Setting: _____

SMAW Butt Weld Check List

Date: _____

Instructor: _____

Period: _____

Inspection Criteria

Student Names	Complete root pass penetration	Complete root pass with no undercut	Good re-in	Should pass bend test	Should pass visual inspection	Should pass cut and etched	Score	Remarks

Material: _____

Consumable: _____

Machine Setting: _____

SMAW Fillet Weld Check List

Date: _____

Instructor: _____

Period: _____

Student Names	Inspection Criteria							Score	Remarks
	Uniform appearance	Good penetration bead	No undercut	Minimal distortion	Proper sequence	Proper bead joint			

Material: _____

Consumable: _____

Machine Setting: _____

SMAW Fillet Weld Horz. Check List

Date: _____

Instructor: _____

Period: _____

Inspection Criteria

Student Names	Uniform bead appearance	Good penetration	No undercut	Minimal distortion	Proper bead sequence	Proper joint fit-up	Score	Remarks

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Material: _____

Consumable: _____

Machine Setting: _____

Smaw Horz. Stringer Bead Check List

Inspection Criteria

Date: _____

Instructor: _____

Period: _____

Student Names	Uniform width	Uniform height	Restrike area uniformity	Filled craters	Beads straight	Beads parallel	No undercut	No weld slag	Weld tie into parent stock	Score	Remarks

Material: _____

Consumable: _____

Machine Setting: _____

SMAW Horz. Butt Weld Check List

Inspection Criteria

Date: _____

Instructor: _____

Period: _____

Student Names	Uniform root pass	No undercut	No weld sag	No slag inclusion	Good tie-in to parent stock	Score	Remarks

Material: _____

Consumable: _____

Machine Setting: _____

SMAW Vert. Stringer Bead Check List

Inspection Criteria

Date: _____

Instructor: _____

Period: _____

Student Names	Bead uniformity	Bead straightness	Bead parallelism	Weld drip or sag	Tie-in	Penetration	No slag inclusion	Even ripple incrementation	Score	Remarks

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UNIT VII

GAS TUNGSTEN ARC WELDING

(GTAW)

INTRODUCTION

The Gas Tungsten Arc Welding process (GTAW), utilizes an electric arc that is struck between the work piece and a non-consumable electrode. The arc is contained within an inert gas envelope to protect the molten weld pool from environmental contamination.

COMPETENCIES

1. Develop an understanding of the GTAW process.
2. Recognize the advantages and limitations of the GTAW process.
3. Identify the equipment, conditions and consumables utilized in the GTAW process.
4. Perform the GTAW process, including striking an arc, torch motion, filler application, butt welds, fillet welds, positioning, and special applications.

GENERAL PERFORMANCE OBJECTIVES/GOALS

1. Develop an understanding of the GTAW process, its advantages, and limitations.
2. Understand the hazards associated with the GTAW process.
3. Be able to identify the components of a GTAW system and explain the components in terms of function.
4. Explain the criteria for current selection with the GTAW process.
5. Relate equipment setting to the desired results for the GTAW process.
6. Be able to set up and weld with the equipment associated with the GTAW process.

7. Be able to recognize and evaluate defects associated with the GTAW process.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will demonstrate their understanding of the GTAW process on multiple choice tests, with a score of 75%.

2. On a written examination, the students will be able to match the specific hazard found in the GTAW process with the correct personal protective equipment and/or procedure needed to neutralize that hazard, with an accuracy of 100%.

3. On a written examination, the students will be able to recognize defects associated with the GTAW process and match the defects with probable cause, with an accuracy of 70%.

4. The students will be able to identify and select components for the GTAW process depending upon application and condition of the weld, with an accuracy of 75%.

5. On a written examination, the students will be able to match current characteristics to proper applications, with an accuracy of 75%.

6. On a practical examination, the students will be able to preset equipment and components involved with the GTAW system, with an accuracy of 75%.

7. With preset equipment, the students will accomplish GTAW welds in the following sequence: butt joint, outside corner joint, lap joint, tee joint with aluminum and inspect according to stated criteria, with an accuracy of 75%.

METHODOLOGY

This unit will present the concepts of Gas Tungsten Arc Welding. Emphasis will be placed on practical lessons and on numerous projects which will enable the students to experience common tasks in GTAW.

SUGGESTED INTEREST APPROACHES

1. Invite a guest speaker to talk to the class concerning the unique advantages of the GTAW process.

2. Show films on the use of the GTAW process as it relates to the joining of exotic metals common to Louisiana's extensive petro/chemical industry.

3. Have the students generate safety posters concerning GTAW.

4. Have the students prepare research papers and give short presentations on the advantages and benefits of the GTAW process.

UNIT OUTLINE

GAS TUNGSTEN ARC WELDING

I. Introduction

A. Origin

B. Place in industry

C. Economic significance

D. Future of GTAW

II. Equipment Nomenclature and Function

A. Power supplies

B. Coolant source

C. Gas source

D. Cabling

E. Torch
1. electrode
2. cups
3. collets

III. Safety Hazards Associated with GTAW

A. Excessive light generated by the GTAW process

B. Oxygen displacement with welding gas

C. Helium inhalation hazards

D. Hot metal hazard

E. Hot torch hazard

IV. Consumable Selection

A. Electrode
1. classification
2. composition
3. diameter
4. application

B. Gases
   1. classification
   2. composition (mixes)
   3. flow rate
   4. application

V. Setup of GTAW System

A. Power supply

B. Gas supply

C. Flow meter (regulator)

D. Coolant

E. Cabling

F. Torch

G. Electrode

H. Gas cup

VI. Welding with GTAW System

A. Equipment preset
   1. amperage
   2. voltage
   3. gas flow
   4. torch cup
   5. electrode
      a) proper angle
      b) proper stick out
   6. coolant

B. Strike arc

C. Welding
   1. padding exercise
   2. corner joint
   3. tee-joint (aluminum)
   4. butt weld (aluminum)
   5. tee-joint (steel)

VII. Inspection

A. Visual check (check list)

B. Etching

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. On a written examination, the students will demonstrate their understanding of the GTAW process on multiple choice tests, with a score of 75%.

Subject Matter Area	Learning Activity
The GTAW Process	1. Using audiovisual, presentation, lecture, and equipment for class demonstrations, the instructor will introduce the GTAW process.
	2. Explain how this process differs from other welding processes.
	3. List advantages and disadvantages, as well as equipment and configurations needed for performance in the GTAW process.

2. On a written examination, the students will be able to match the specific hazard found in the GTAW process with the correct personal protective equipment and/or procedure needed to neutralize that hazard, with an accuracy of 100%.

Subject Matter Area	Learning Activity
Hazards Associated with the GTAW Process	1. With audiovisual presentations, lecture, and/or equipment demonstrations, welding safety will be reviewed. Special emphasis will be placed on the brighter arc generated, oxygen

displacement, and pressurized cylinders associated with the GTAW process.

3. On a written examination, the students will be able to recognize defects associated with the GTAW process and match the defects with probable cause, with an accuracy of 70%.

Subject Matter Area	Learning Activity
Weld Defects	1. Through the use of audiovisual presentations and specimen exhibition, the students will view and learn the defects associated with the GTAW processes. These defects should include, but not be limited to the following: a. Poor arc ignition and maintenance b. Arc wander c. Tungsten contamination d. Frosted or contaminated welds e. Equipment overheating and destruction f. Porosity g. Lack of fusion h. Undercutting i. Cracking j. Unacceptable bead conformation

4. The students will be able to identify and select components for the GTAW process depending upon application and condition of the weld, with an accuracy of 75%.

Subject Matter Area	Learning Activity
Component Selection for the GTAW Process	1. Utilizing audiovisual, presentations, and demonstrations with actual components, the students will be able to select components such as electrodes, electrode diameter, and composition, gases, filler metal, and cups according to the type of weld requirement.

5. On a written examination, the students will be able to match current characteristics to proper applications, with an accuracy of 75%.

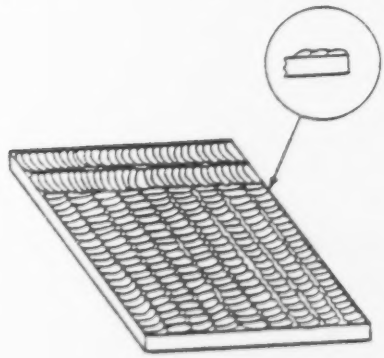
Subject Matter Area	Learning Activity
Current Selection	1. Utilizing audiovisual presentations, and equipment demonstrations, the instructor should demonstrate welding with AC and DCSP current matching each current selection with the type of welding characterized by each type of current. The instructor also needs to demonstrate what happens to the weld when the wrong current selection is made.

Note: A one shade darker lens should be used when utilizing the GTAW process, because of the brighter arc experienced with the GTAW process.

6. On a practical examination, the students will be able to preset equipment and components involved with the GTAW system, with an accuracy of 75%.

Subject Matter Area

Preset GTAW Equipment



Learning Activity

1. With demonstrations on actual equipment, the instructor will demonstrate equipment setup for welding on aluminum, stainless steel, and carbon steel. Settings should be mid-range. Filler material must be metallurgically compatible with the parent metal being welded.

7. With preset equipment, the students will accomplish GTAW welds in the following sequence: butt joint, outside corner joint, lap joint, tee joint with aluminum and inspect according to stated criteria, with an accuracy of 75%.

Subject Matter Area

Welds with the GTAW Process

Learning Activity

1. Demonstrate Padding Exercise (Aluminum)

Material:

1pc. 1/4" x 4" x 6" Aluminum Plate 6016-T6 or 5052

Filler Material:

3/32" 1/16 dia. 4043 or 5356

Note: Cut rod in half for easier manipulation.

Machine Setting:

AC/HF Continuous Medium Range
Panel/Remote: Remote
Gas - Argon 15CHF w/No. 16 cup

Electrode:

Tungsten: Pure color code green 3/32" dia. for 1/8"

Procedure:

1. Remove oxide with an appropriate wire brush. A brush made of stainless steel is recommended.

Note: Appropriate eye protection is needed for oxide removal.

2. Run first bead along edge (6") and subsequent beads parallel to and fused with first bead.

3. Fill first side, let cool, brush, and inspect weld.

4. Turn coupon over and repeat exercise.

5. Allow the coupon to cool, then clean and begin third pass on side one starting on the short edge (4").

6. Let coupon cool and repeat step 5 on side 2.

7. The end product should be on the coupon with two

layers built up on both sides.

Inspection:

1. Coupon should be a uniform thickness of 1/2".

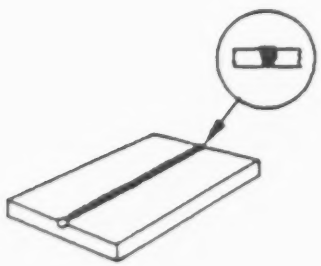
2. Beads should be of uniform height and width.

3. Bead ripples should have uniform incrementation.

4. Built up pad should have square edges, without rollover.

Subject Matter Area

Butt Joint with the GTAW Process



Learning Activity

Presentation and procedure for Butt Joint (Aluminum)

Material:

2pcs. 1/8" x 2" x 6"
2pcs. 1/16" x 2" x 6"

Filler Material:

1 rod 1/8" dia.
1 rod 1/16" dia. (4043 or 5356)

Machine Setting:

AC/HF Continuous Medium Range
Panel/Remote: Remote
Gas - Argon 15CHF w/No. 16 cup

Electrode:

Tungsten: Pure Color code green 3/32" dia.

for 1/8"; 1/16" dia. for welding 1/16" coupon

Procedure:

1. Remove oxide with stainless steel wire brush in the immediate area of the weld or along edges to be welded on the 1/8" coupons.

2. Tack coupon at each end leaving no space. Additional tack may be used to insure nonseparation of coupons due to heat distortion.

3. Run bead starting inside of end tack.

Note: Do not strive for full penetration on first attempts. Full penetration should only be attempted after students have confidence in their ability concerning this process. On final attempts, the joint should show full penetration.

4. Repeat the above procedure using 1/16" coupons, 1/16" electrode, 1/16" filler rod, and low amperage.

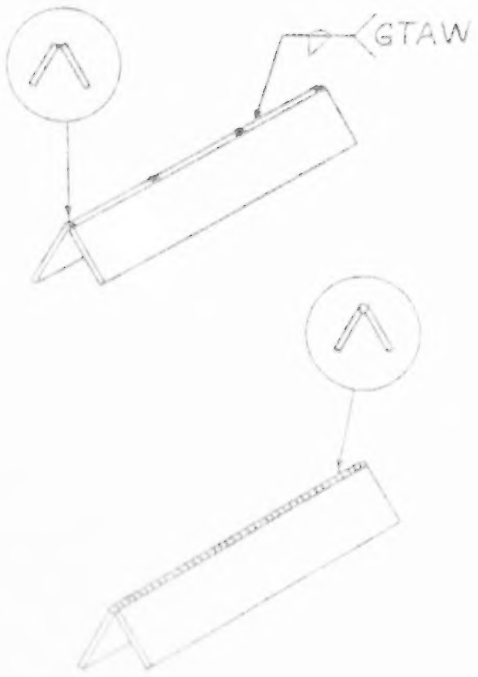
Inspection:

1. Bead should be straight with even ripple segmentation.

2. Penetration should be even and consistent on the reverse side.

Subject Matter Area

Outside Corner Joint with the GTAW Process



Learning Activity

Demonstration by instructor

Welding by students

Presentation and procedure for Outside Corner Joint (Aluminum)

Material:

2pcs. 1/8" x 2" x 6"
2pcs. 1/16" x 2" x 6"
Aluminum (5052)

Filler Material:

1ea. 3/32" dia. No. 4043 or 5356
1ea. 1/16" dia. No. 4043 or 5356

Machine Settings:

AC/HF Continuous Medium Range
Panel/Remote: Remote
Gas - Argon 15CFH w/No. 16 cup
Tungsten 3/32" dia.
Pure Tungsten color code green for 1/8" material, use 1/16" tungsten for thinner material.

Procedure:

1. Remove oxide in area of weld.

2. Tack weld on ends and in middle to maintain joint alignment.

3. Run a bead the length of the coupon at the area of junction.

4. Joint should exhibit full penetration.

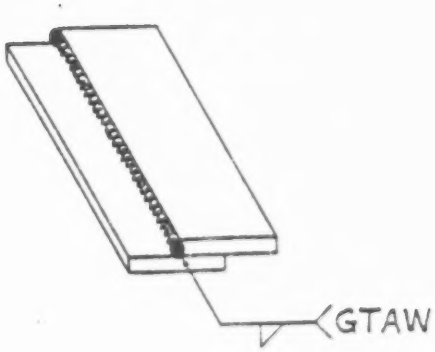
Inspection:

1. Bead should exhibit smooth and even ripple segmentation of even width.

2. The crown of the welded bead should be high enough so that the outside radius of the crown is equal to the thickness of the material.

Subject Matter Area

Lap Joint with the GTAW Process



Learning Activity

Presentation and procedure for a Lap Joint (Aluminum)

Material:

3pcs. 1/8" x 2" x 6"
3pcs. 1/16" x 2" x 6"
Aluminum (5052)

Filler Material:

3/32" 1/16 dia. 4043 or 5356

Machine Setting:

AC/HF Continuous Medium Range
Gas - Argon 15CHF w/No. 16 cup
Tungsten: Pure Color code green 3/32" dia. for 1/8" material, 1/16" dia. for 1/16" material.

Procedure:

1. Remove oxide with stainless steel brush at area of weld.

2. Overlap two 1/8" coupons 1".

3. Tack on ends of the coupon and once in the middle to prevent heat distortion.

4. Continuous weld in areas indicated.

5. Run beads in areas indicated without interruption.

Inspection:

1. Bead should be smooth with uniform width and even ripple incrementation.

2. There should be no scalloping along the top edge of weld.

3. There should be no burn-through on the opposite side of the weld.

4. There should be definite heat marks on the opposite side of the weld indicating adequate penetration.

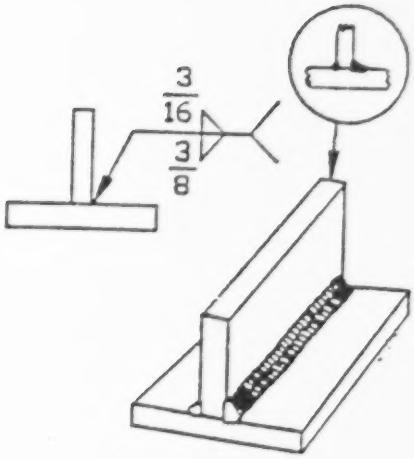
Subject Matter Area

Tee Joint Construction with the GTAW Process

Learning Activity

Presentation and procedure

Materials:



Fillet Weld
Horizontal (2F) Position

3pcs. 1/8" x 2" x 6"
3pcs. 1/16" x 2" x 6"
Aluminum (5052)

Filler Material:

3/32" 1/16" dia. 4043 or 5356

Machine Setting:

AC/HF Continuous Medium Range
Gas - Argon 15CHF w/ No. 16 cup
Tungsten: Pure, Color code, green 3/32" dia. for 1/8" material, 1/16" dia. for 1/16" material.

Procedure:

1. Remove oxide with stainless steel brush at area of weld.

2. Position material and tack weld as indicated.

3. Run a bead the full length of the coupon.

Inspection:

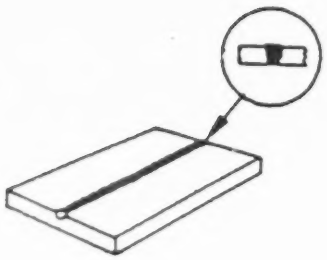
1. Bead should be smooth, even width on ripple incrementation.

2. There should be no undercutting or burn-through.

3. The fillet weld size should conform to the specified criteria of 3/16" on 1/8" material.

Subject Matter Area

Butt Weld with the GTAW Process



Learning Activity

Presentation and Procedure for Butt Weld with the GTAW Process (Steel)

Material:

2pcs. 1/16" x 2" x 6" 1018-1020 low carbon steel; cold rolled steel is preferred because of the absence of mill scale.

Filler Material:

1pc. 1/16" dia. AWS E70S -2 welding rod 18" in length.

Machine Setting:

DSSP Start Only
Medium to low range
Panel/Remote: Remote
Tungsten EWTH1 or EWTH2 color code red or yellow
Gas-Argon 15CFH w/No. 16 Gas Cup

Procedure:

1. Remove grease and oils with suitable solvent. Remove oxides and mill scale for best results.

2. Tack weld coupon along 6" edge. With no space between coupons weld entire length of joint without stopping.

Inspection:

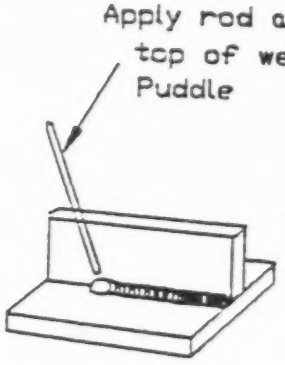
1. Bead should be smooth, shiny, clean and uniform width for the entire length of the weld.

2. Ripples should be of even incrementation with no porosity.

3. This weld should display no undercut and there should be only minimal melt through on the reverse side of the weld.

Subject Matter Area

T-Joint with the GTAW Process (Steel)



Learning Activity

Presentation and procedure for T-Joint construction utilizing the GTAW Process (Steel).

Materials:

2pcs. 1/8" x 2" x 6" 1018 -1020 low carbon steel; cold rolled preferred because of the absence of mill scale.

Filler Material:

1pc. 1/16" dia. AWS E70S -2 welding rod 18" in length.

Machine Settings:

DSSP Start Only
Medium to low range
Panel/Remote: Remote
Tungsten EWTH1 or EWTH2 color code red or yellow
Gas - Argon 15CFH w/No. 16 Cup

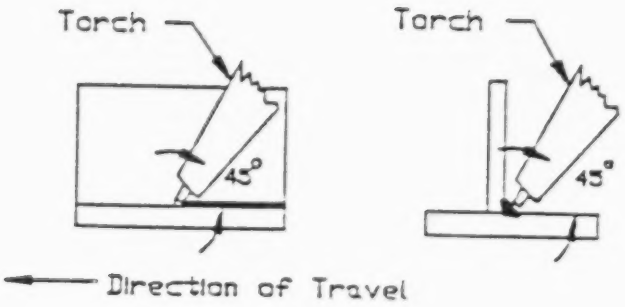
Procedure:

1. Remove grease, oil, and oxide.
2. Tack weld pieces in "T" configuration.
3. Run bead length of weld at intersection of pieces.

Note: 1. Work piece should be tacked to table.
2. Attention must be given to torch angle.

Inspection:

1. Weld should show even ripple incrementation and be of uniform width.
2. Weld surface should be bright without undercut and porosity or splatter.
3. There should be no melt-through; however there may be heat discoloration on the opposite side of the weld. Also the perpendicular piece may pull out of register toward the side of the weld.
4. Fillet size should be no more than 3/16" maximum.



Proper Torch Orientation fo Fillet Welds

GAS TUNGSTEN ARC WELDING

TEST

SETUP, OPERATION, AND FILLER MATERIAL

Matching I: Match welding gas to application.

A. Argon B. Argon/Helium (mix) C. Helium

_____ 1. Aluminum up to 1/4" thick

_____ 2. Copper up to 1/8" thick

_____ 3. Monel over 1/8" thick

_____ 4. Stainless Steel

_____ 5. Low Carbon Steel 1/4 - 1/2"

_____ 6. Magnesium up to 1/4" thick

Matching II: Match filler rod to welded alloy.

A. 5356 or 5154 B. 1100 C. 5556 D. 4343 or 5356

_____ 7. 3003 aluminum

_____ 8. 5052 aluminum

_____ 9. 5086 aluminum

_____ 10. 6061 aluminum

Matching III: Match electrode to color code.

A. Brown B. Red C. Yellow D. Green

_____ 11. Pure Tungsten

_____ 12. Zirconium

_____ 13. 1% Thoriated

_____ 14. 2% Thoriated

Matching IV: Match tungsten electrode to its application or characteristic.

A. Brass and Copper Alloys
B. Premium-smoothest Action
C. Aluminum
D. Steel Alloys

_____ 15. Zirconium

_____ 16. 1% Thoriated

_____ 17. 2% Thoriated

_____ 18. Pure Tungsten

UNIT TEST

ANSWER KEY

GAS TUNGSTEN ARC WELDING

Matching I:	1.	A
	2.	A
	3.	C
	4.	A
	5.	B
	6.	A
Matching II:	7.	B
	8.	A
	9.	C
	10.	D
Matching III:	11.	D
	12.	A
	13.	C
	14.	B
Matching IV:	15.	B
	16.	A
	17.	D
	18.	C

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit exam.
2. Student projects.
3. Safety posters.
4. Student research papers.
5. Student presentations.

EQUIPMENT AND SUPPLIES

Student	Teacher
Pencil	Chalkboard, chalk, eraser
Notebook	Audiovisual equipment
Textbook	Textbook
Safety glasses	Lesson plan
Safe clothing	Curriculum guide
	Safety glasses
	GTAW equipment
	GTAW supplies

BULLETIN BOARD IDEAS

1. Post safety rules for GTAW.
2. Display product literature from various manufacturers.
3. Display student safety posters.
4. Post clean-up rules and assignments for GTAW.

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UNIT VIII

GAS METAL ARC WELDING

(GMAW)

INTRODUCTION

Gas Metal Arc Welding (GMAW), also known as metal inert gas welding or MIG, uses a continuous feed wire electrode to form the arc and to provide filler material to the weld area. This process also utilizes a gas shield to protect the weld area from atmospheric contamination. This process can be utilized as a hand held semiautomatic system where the welder controls travel speed and the angle of the GMAW torch or gun. This process can also be used in a fully automatic configuration where the travel speed and torch angle are maintained by a mechanical holding and manipulation device.

COMPETENCIES

1. Compare the GMAW process to other welding processes.
2. Identification of safety hazards encountered with GMAW.
3. Explanation of GMAW components in terms of function.
4. Be able to weld with the GMAW process.
5. Recognition of weld defects associated with the GMAW process.

GENERAL PERFORMANCE OBJECTIVES

1. Develop an understanding of the GMAW process.
2. Comprehend and be able to neutralize the hazards associated with the GMAW process.
3. Be able to identify and explain the components utilized with the GMAW process, in terms of function.
4. Be able to identify the consumables and list the selection criteria for the consumables utilized in the GMAW process.

5. Be able to accomplish the GMAW process.

6. Be able to recognize and eliminate the causes of common defects associated with the GMAW process.

7. Set-up equipment and execute the following welds in accordance with the conditions set forth in the inspection criteria as listed.

8. Recognition and correctional procedures of defects associated with the GMAW process.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. On a written examination, the students will demonstrate their knowledge of the GMAW process, with an accuracy of 75%.

2. On a written examination, the students will demonstrate their understanding of the hazards associated with the GMAW process by matching hazards with a corrective procedure, with an accuracy of 100%.

3. On a written examination, the students will be able to match the component of a GMAW system with its function, with an accuracy of 70%.

4. On a written examination, the students will be able to identify the consumables used in the GMAW process and state the selection criteria for each type, with an accuracy of 70%.

5. With proper supervision, demonstrations, and practice, the students will be able to accomplish the specified GMAW welding procedure in accordance with the stipulated inspection criteria, with an acceptance rate of 70%.

METHODOLOGY

Gas Metal Arc Welding (GMAW) is an extremely efficient process. Because a shielding gas and a welding "wire" are used, the weld can be performed very fast with little or no weld cleaning required. This unit will provide the students with the knowledge and practice necessary to develop basic competency in GMAW. The instructor will provide detailed lessons on the GMAW

process, keeping in mind to stress the hazards associated with the process. A group demonstration should follow. Students should be required to complete projects which demonstrate their knowledge and skill concerning the SMAW process.

SUGGESTED INTEREST APPROACHES

1. Invite a guest speaker to talk to the class on the unique advantages of the GMAW process.
2. Show a film on the GMAW process.
3. Have students prepare a bulletin board display concerning the GMAW process.
4. Have students prepare research papers on the GMAW process and give class presentations.

UNIT OUTLINE

GAS METAL ARC WELDING

(GMAW)

I. Introduction

- A. Origin
- B. Place in industry
- C. Economic significance
- D. Safety

II. Equipment Nomenclature and Function

- A. Power supply
- B. Wire feeder
- C. Gas supply
  1. cylinders
  2. regulators
  3. hoses
- D. Water supply (optional)

E. Leads

F. Torch
   1. push
   2. pull

III. Consumables

A. Gases
   1. type
   2. purpose

B. Wire
   1. classification
   2. purpose
   3. diameter

IV. Welding with the GMAW System

A. Set up

B. Procedure variables
   1. torch speed travel
   2. direction of torch movement
      a. forehand
      b. backhand
   3. torch angle
   4. nozzle to work distance (stick out)
   5. weave pattern

C. Flat butt weld (steel and aluminum)
   1. materials
   2. consumables
      a. gas
      b. wire
   3. machine set up
   4. specimen placement
   5. procedure
   6. evaluation

D. Horizontal T-joint (steel and aluminum)
   1. materials
   2. consumables
      a. gas
      b. wire
   3. machine set up
   4. specimen placement
   5. procedure
   6. evaluation

SPECIFIC PERFORMANCE OBJECTIVES
AND LEARNING ACTIVITIES

1. On a written examination, the students will demonstrate their knowledge of the GMAW process, with an accuracy of 75%.

Subject Matter Area	Learning Activity
GMAW	1. With audiovisual presentations, explain the GMAW process.
	2. With actual on-equipment demonstrations, explain the GMAW process in terms of weld characteristics and industrial application.
	3. In a lecture setting, explain the advantages, disadvantages, and economic impact of the GMAW process.

2. On a written examination, the students will demonstrate their understanding of the hazards associated with the GMAW process by matching hazards with a corrective procedure, with an accuracy of 100%.

Subject Matter Area	Learning Activity
Hazards of GMAW	1. With audiovisual presentations and on-equipment demonstrations, explain the hazards associated with the GMAW process.
	2. Have the students construct safety posters depicting

hazards associated with the GMAW process.

3. Bring in an outside speaker from industry to illustrate the hazards associated with the GMAW process.

3. On a written examination, the students will be able to match the component of a GMAW system with its function, with an accuracy of 70%.

Subject Matter Area	Learning Activity
Component Function of a GMAW Process	1. With audiovisual presentations and on-equipment demonstrations, the students will be able to discuss the nomenclature and function of the various GMAW components.
	2. In the welding lab, demonstrate to the students the correct assembly and adjustment procedures for the GMAW equipment.
	3. Have the students practice assemblying and adjusting the GMAW equipment.

4. On a written examination, the students will be able to identify the consumables used in the GMAW process and state the selection criteria for each type, with an accuracy of 70%.

Subject Matter Area	Learning Activity
Consumables for the GMAW Process	1. Discuss with the students the various

consumables used in the GMAW process and their selection criteria.

2. Distribute manufacturers' literature concerning special purpose GMAW consumables.

3. Demonstrate to the students the various characteristics of the consumables by performing various types of welds.

4. For laboratory use, the students can develop a bulletin board presentation that will identify the AWS system of wire filler metals and their use pertinent to the GMAW process.

5. With proper supervision, demonstrations, and practice, the students will be able to accomplish the specified GMAW welding procedure in accordance with the stipulated inspection criteria, with an acceptance rate of 70%.

Subject Matter Area	Learning Activity
Welding with the GMAW Processes	1. After demonstrations in material, consumable selection, making settings, and welding, the students will accomplish the following welds: Padding Corner Weld Lap Weld Deep Groove

Multi-pass
Flat Weld

Note: It is suggested that the use of short-arc as opposed to spray-arc method of transfer be used, because of the cost of equipment. Also most constant voltage 100% duty cycle standardized welding machines can be retrofitted with a wire feeder to perform GMAW welding.

The students will be able to accomplish the following GMAW welds according to the specified inspection criteria.

1. Flat Butt Weld (steel)
2. Horizontal T-Joint (steel)

FLAT BUTT WELD

Material:

2pcs. 1/8" x 2" x 6" mild steel
1pc. 1/8" x 1" x 6" mild steel

Consumables:

Filler--AWS E705-3 .035 dia.
Shielding Gas--(C-25 or CO2) 30 CFH

Machine Setting:

Set flat slope for short arc metal transfer
Voltage--Flat position 10-20 volts
Wire Feed--150 to 155 Amps

Set Up:

1. Set up 2" stock with a 3/16" root opening clamped to the 1" backing strip.

2. Make a single pass, forehand or backhand for the length of the coupon.

Inspection Criteria:

1. Weld should have a smooth bead with even incrementation of weld ripple.

2. The crown should not be excessive. Excessive crown is indicative of slow travel speed.

3. Penetration should extend well into the backing strip without burn-through.

4. The parent stock should have no under-cutting at the edge of the weld.

GMAW

HORIZONTAL T-JOINT

(STEEL)

Material:

2pcs. 1/8" x 2" x 12" mild steel

Consumables:

Filler--AWS E705-3, .035 dia.
Shielding Gas--C-25 or CO2

Machine Setting:

Set slope for short arc.

Voltage setting 18-20 volts.
Minimum inductance.

Wire feed adjusted for 155-165 Amps.
Shield Gas 30 CFH.

Procedure:

1. Set up coupons in T-joint configuration.

2. Tack 3 spots along the face of the weld. Tack 3 spots along back side of weld, to negate the effects of distortion caused by heat input.

3. With forehand technique, make a single pass.

Note: Torch should be angled away from direction of travel no more than 20 degrees.

Inspection:

1. Bead should be even with even weld incrementation.

2. Fillet should be 1/4" across the face.

3. There should be no undercutting on the parent stock at the toes of the weld.

GMAW TEST

SAFETY

Match the injury to the procedure used to eliminate the possibility of that injury.

_____	1.	Machine Grounding	A. Eye injury caused by cut wire stub
_____	2.	Darker Lens	B. Cut gloves or fingers
_____	3.	Carbon Dioxide (CO_2)	C. Bleeding from nose and throat
_____	4.	Helium	D. Oxygen displacement
_____	5.	Sharp Wire (after trimming)	E. Brighter arc
			F. Electrical shock
_____	6.	Contraction of welding slag	G. Eye injury caused by slag
_____	7.	Flying wire stubs caused by trimming	

List as A = Advantages over SMAW and
B = Disadvantages over SMAW

_____ 8. Penetration

_____ 9. Disposition rate

_____ 10. Skill level of operator

_____ 11. Cost of set up

_____ 12. Availability of consumables

_____ 13. Cost of welding

UNIT TEST

SAFETY

ANSWER KEY

Matching:

1. F
2. E
3. D
4. C
5. B
6. G
7. A

List:

8. B
9. A
10. A
11. B
12. A
13. A

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Unit exam.
2. Quizzes.
3. Student projects.
4. Safety posters.
5. Student reports/presentations.

EQUIPMENT AND SUPPLIES

Student	Teacher
Pencil	Chalkboard, chalk, eraser
Notebook	Audiovisual equipment
Textbook	Textbook
Safety glasses	Lesson plan
Safety clothing	Curriculum guide
	Safety glasses
	GMAW equipment
	GMAW supplies

BULLETIN BOARD IDEAS

1. Post safety rules for GMAW.
2. Display GMAW product literature.
3. Display student safety posters.
4. Post clean-up rules and assignments for GMAW.

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Giachino, J. W. & Weeks, W. R. (1985). Welding skills (pp. 230-261). Homewood, IL: American Technical Publishers.

Gosse, J. (1985). Welding skills workbook (pp. 200-206). Homewood, IL: American Technical Publishers.

Jeffurs, L., & Johnson, H. V. (1988). Welding principles and applications (2nd ed.) (pp. 277-330). Albany: Delmar.

Smith, D. (1984). Welding skills and technology (pp. 420-460). New York: Gregg Division, McGraw-Hill.

UNIT IX

SPECIAL PROJECTS

INTRODUCTION

This unit will enable the students to take an active part in research and presentation of selected areas of welding. Depending upon the length of time spent on this unit, two or more of the following areas can be explored. Special projects will encourage students to pursue independent study. Rather than teaching this unit at one time during the year, the instructor may elect to pull various units at different times as appropriate. For example, the safety posters would fit in well within the framework of the safety unit!

COMPETENCIES

1. Define and analyze special project units.
2. Develop and present projects dealing with research, safety, process display, and technical speaking.

GENERAL PERFORMANCE OBJECTIVES/GOALS

1. Identify special project units.
2. Select and use various reference materials effectively.

SPECIFIC PERFORMANCE OBJECTIVES AND MASTERY CRITERIA

1. The students will give a three to five minute speech fifteen minutes after having drawn a card on which a topic for their speech is written, with 75% accuracy.
2. The students will present a speech of three to five minutes in length on a topic related to the welding industry with 75% accuracy.
3. The students will select and research an Industrial Arts/Technology Education related topic and present a written report, with 75% accuracy.

4. The students will produce a safety poster on a given size sheet using artistic expressions, with 75% accuracy.

5. The students will read and analyze technical articles and write a comprehensive report summarizing the key elements of the articles, with 75% accuracy.

6. The students will construct a display on industrial or technical process within a defined area, with 75% accuracy.

METHODOLOGY

This unit has been designed to allow the students to become proficient in the research and presentation of new information. Emphasis has been placed on both speaking and writing ability as this unit conforms to both TSA and LIASA guidelines. The instructor may want to enter his student(s) in state and national competition. For additional information, the instructor should contact the Industrial Arts/Technology Education Section Chief, Office of Vocational Education, Louisiana State Department of Education.

SUGGESTED INTEREST APPROACHES

1. Inform the students of the great importance of expressing oneself clearly in both speaking and writing.

2. Have the industrial arts club president at your school explain the special projects competitive events held at state and national industrial arts student conferences.

UNIT OUTLINE

SPECIAL PROJECTS

I. Extemporaneous Speech

II. Prepared Speech

III. Research Paper

IV. Safety Poster

V. Technical Report Writing

VI. Technology Process Display

SPECIFIC PERFORMANCE OBJECTIVES AND LEARNING ACTIVITIES

1. The students will give a three to five minute speech fifteen minutes after having drawn a card on which a topic for the speech is written, with 75% accuracy.

Subject Matter Area	Learning Activities
Impromptu Speech	1. Demonstrate the ability to communicate verbally to an audience.

2. The students will present a speech of three to five minutes in length on a topic related to industrial or technology fields, with 75% accuracy.

Subject Matter Area	Learning Activities
Memorized Speech	1. Research speech topic and record in outline form. 2. Demonstrate the ability to communicate verbally to an audience.

3. The students will select and research an Industrial Arts/Technology Education related topic and present a written report, with 75% accuracy.

Subject Matter Area	Learning Activities
Research Paper	1. Demonstrate the ability to select and research a topic. 2. Create written communication following an accepted format.

4. The students will produce a safety poster on a given size sheet using artistic expression, with 75% accuracy.

Subject Matter Area	Learning Activities
Safety Poster	1. Demonstrate the ability to recognize safety needs. 2. Communicate a safety message in visual form.

5. The students will read and analyze technical articles and write a comprehensive report summarizing the key elements of the articles, with 75% accuracy.

Subject Matter Area	Learning Activities
Technical Report Writing	1. Demonstrate the procedure for conducting library research. 2. Provide students the opportunity to do self-directed research. 3. Demonstrate the ability to consolidate various information sources into a complete and comprehensive report.

6. The students will construct a display on industrial or technological process within a defined area, with 75% accuracy.

Subject Matter Area	Learning Activities
Display	1. Demonstrate the knowledge of a process by fabricating a display of the researched process.

UNIT TEST

SPECIAL PROJECTS

This unit on Special Projects will not require a unit test because of the variety of formats covered. The students' evaluations will come from the individual grades on each area covered. The unit grade would be an average of the grades acquired.

EVALUATION AND TESTING

Ways to Evaluate Student Growth

1. Give students class participation grades.
2. Speeches will be graded for content and presentations.
3. Research papers will be graded.
4. Displays will be evaluated for content, originality, and overall visual appeal.
5. Safety posters are to be graded.

EQUIPMENT AND SUPPLIES

Student	Teacher
Textbook	Textbook and manual
Notebook	Curriculum guide
Professional magazines	Chalkboard, chalk, eraser
Pen/pencil	Audiovisual aids
Poster paper	Professional magazines
Colored markers	Professional journals
	Access to library materials

BULLETIN BOARD IDEAS

1. Post directions for the various special projects.
2. Post students work as it is submitted.
3. Post TSA/LIASA bulletins, posters, and other materials.
4. Post library materials.

RESOURCE MATERIAL

Resources

American Vocational Association
1410 King Street
Alexandria, VA 22314

Industrial Education Magazine
262 Mason Street
Greenwich, CT 06830

International Technology Education Association
1914 Association Drive
Reston, VA 22091

School Shop Magazine
P. O. Box 8623
Ann Arbor, MI 48107

Technology Student Association
1914 Association Drive
Reston, VA 22091

PROJECT GUIDELINES

The following material was compiled from the American Industrial Arts Student Association Guidelines for Competitive Events. This material can be used in conjunction with the unit material presented. These competitive events are held each year in regions throughout the State.

EXTEMPORANEOUS SPEECH

OVERVIEW: TSA contestants in Extemporaneous Speech are required to give a three- to five-minute speech fifteen minutes after having drawn a card on which a topic for their speech is written.

I. CONTEST PURPOSE

The purpose of Extemporaneous Speech is to provide a means for TSA members to demonstrate their knowledge of and ability to communicate about technology subjects.

II. ELIGIBILITY FOR ENTRY

Entries are limited to two (2) per chapter.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

Each speech shall not be less than three (3) minutes nor more than five (5) minutes. The Contest Coordinator shall introduce the contestants by number only and the contestants may introduce their speech by title only. The timekeeper shall visually notify the speakers of the time remaining by using six separate cards. Each of the six cards shall have a number (4, 3, 2, 2, 1/2, 0) shown in descending order to the contestants by the timekeeper during the speech. Contestants are to be penalized on each judge's score sheet one point per ten (10) seconds for speaking over five (5) minutes or under three (3) minutes. Time commences when the speakers begin talking.

V. SPECIFIC REGULATIONS

Each speech shall be the result of the contestant's own effort, using any reference material which the contestants may bring to the preparation room. No other assistance may be provided. Students will be responsible for bringing their own 3 x 5 notecards to the contest. Any notes for speaking must be made during the fifteen-minute preparation period. While

contestants will be permitted to use notes when speaking, it should be noted that deductions in scoring may be made for this practice if it detracts from the effectiveness of the presentation.

VI. PROCEDURE

A. Registration - Contest participants must register for the event in accordance with procedures established for each conference.

B. Participation Sequence - Students will gather at one location, as identified at registration, to draw for places on the program.

C. Topic Selection - shall be held fifteen (15) minutes before each student enters the preparation room. Each student will draw three cards containing one topic per card from a box and select one topic to speak on, and then return the two unused cards to the box.

D. Preparation

1. After selection of topic, the first student will enter a preparation room, separate from the speech delivery room, and will be given fifteen (15) minutes to prepare his/her speech.

2. Seven (7) minutes after the first student enters the preparation room, the second student will enter the room, go to a different section, and begin his/her speech preparation. Fifteen (15) minutes will be allowed to prepare the speech.

3. All remaining participants will be allowed to enter the preparation room in seven-minute intervals, thus enabling a constant flow of students to speak before the judges in seven-minute intervals. (Allows for one minute to enter room and announce entry number, five minutes for speech presentation, and one minute to exit room.)

E. Introductions - The Contest Coordinator shall introduce each contestant by assigned number in order of the drawing.

F. Audience - Observers will not be allowed in the audience or the performance room during contest heats. Observers will be allowed to sit in the audience of the performance room during the finals only. No talking or gesturing will be permitted. Observers will **NOT** be allowed to enter or leave during a speech. **APPLAUSE SHALL BE WITHHELD UNTIL ALL CONTESTANTS HAVE SPOKEN.**

G. After speaking, the students must return their topic card to the judges.

PREPARED SPEECH

OVERVIEW: TSA contestants in Prepared Speech are required to deliver a memorized speech of three (3) to five (5) minutes in length on a topic related to industrial or technology fields.

I. CONTEST PURPOSE

The purpose of the Prepared Speech contest is to provide a means for TSA members to demonstrate their ability to communicate verbally to an audience.

II. ELIGIBILITY FOR ENTRY

Entries are limited to two (2) per chapter.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

Each speech shall not be less than three (3) minutes or more than five (5) minutes. The Contest Coordinator shall introduce the contestants by number only and the contestants may introduce their speech by title only. The timekeeper shall visually notify the speakers of the time remaining by using six separate cards. Each of the six cards shall have a number (4, 3, 2, 1, 1/2, 0) shown in descending order to the contestants by the timekeeper during the speech. Contestants will be penalized on each judge's score sheet one point per each ten-second interval of speaking over or under

the allotted time. Time commences when the speakers begin talking.

V. SPECIFIC REGULATIONS

A. Each speech shall be the result of the contestant's own efforts, utilizing any reference materials which the contestant wishes to use.

B. Topic selection - Contestants may choose the subject for their speech; however, the subject must pertain to TSA and/or be related to Industrial Arts/Technology Education.

C. A bibliography **MUST** be submitted to the judges before presenting the speech. Ten (10) points shall be deducted for contestants who fail to submit a bibliography.

D. Contestants may use two 3 x 5 cards for notes. However, deductions in scoring may be made for this practice if it detracts from the effectiveness of the presentation.

E. Contestants will not be allowed to hear presentations of other contestants.

VI. PROCEDURE

A. Registration - Contest participants must register for the event in accordance with procedures established for each conference.

B. Participation Sequence - Students will gather at one location as identified at registration to draw/sign-up for speaking times.

C. Introduction - The Contest Coordinator shall introduce each contestant by number and in order of the drawing.

D. Audience - Observers other than contestants will be allowed to sit in the audience of the performance room. No talking or gesturing will be permitted. Observers will **NOT** be allowed to enter or leave during a speech. **APPLAUSE SHALL BE WITHHELD UNTIL ALL CONTESTANTS HAVE SPOKEN.**

VII. REQUIRED CONTEST PERSONNEL AND EQUIPMENT

A. Contest Coordinator

B. Judges - three (3) per heat

C. Two (2) timekeepers per level shall be designated who will record the time used by each contestant in delivering their speech. The timekeepers will note to the judges any undertime or overtime for which deductions should be made and inform the contestants of the amount of time remaining in minutes by using 5 x 7 cards with the numbers 4, 3, 2, 1, 1/2, and 0 placed on them and shown to the contestants throughout the speech. Time shall be indicated to the contestants throughout the speech, in descending order.

D. Materials and equipment supplied by the committee:

1. Speaker's stand
2. Stopwatches for timekeepers
3. Table and chairs for 3 judges
4. Rating sheets for judges furnished by Competitive Events Coordinator
5. Chairs for audience
6. One set of six 5 x 7 cards with one of the following number on each card: 4, 3, 2, 1, 1/2, and 0.

RESEARCH PAPER

OVERVIEW: TSA members entering the Research Paper contest are required to research an Industrial Arts/Technology Education related topic which they select and present a written paper on the topic.

I. CONTEST PURPOSE

The purpose of the Research Paper contest is to provide a means for TSA members to demonstrate their ability to select a topic, research the topic, and create written communication following an accepted format.

II. ELIGIBILITY FOR ENTRY

Entries are limited to two (2) per chapter.

III. LEVEL OF COMPETITION
Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

While this is not a "timed" event, all schedules must be adhered to as presented in Sections V and VI.

V. SPECIFIC REGULATIONS

A. The research paper is an individual project. No recognition will be given to a group effort.

B. The introduction, review of related literature, and conclusion shall be limited to ten (10) pages.

C. Charts, tables, drawings, diagrams, and short reprints of reference material are to be placed in the appendix. The appendix will not count as part of the ten (10) pages of the research paper.

D. A bibliography of ALL references used is to be included. This also will not count as part of the ten (10) pages of the research paper.

E. The basic outline shall include:

Title Page (which must be removable for judging)
Table of Contents
Introduction (include title above the Introduction section)
Review of Literature
Conclusion
Endnotes/Footnotes, if applicable

F. The research paper shall be typewritten, double spaced, on one side of good-quality 8 1/2" x 11" plain white paper.

G. The topic of the research paper may be related to any aspect of Industrial Arts/Technology Education.

H. The title page is to be included at the beginning of the paper, using the following format: (NOTE: The title of the research paper

must also be listed at the top of the first page of the research paper.)

TITLE OF PAPER

being

A Paper Entered in the

RESEARCH PAPER CONTEST

by

Put Your Name Here
Home Address

Chapter Name _____ Level _____

School Name _____ Grade _____

School Address _____ Entry Number _____
(assigned by Coordinator)

_____

Date _____ Approved _____
TSA Local Advisor

I. The title page will not count as one of the ten (10) pages of the research paper.

J. Contestants may not have entered this research paper at any previous National Conference.

K. Three (3) copies of the research paper shall be mailed to the Competitive Events Coordinator by the present deadline date. NOTE: NO ENTRIES WILL BE ACCEPTED THAT ARE POSTMARKED BEYOND THE DEADLINE DATE. (It is advisable to keep an additional copy of the research paper.)

SAFETY POSTER

OVERVIEW: Safety Poster is designed to direct member attention to the area of laboratory safety. Contestants are required to produce a safety poster on a given size sheet using artistic expression.

I. CONTEST PURPOSE

The purpose of the Safety Poster contest is to provide a means for TSA members to demonstrate their ability to recognize safety needs and to communicate safety messages in visual form.

II. ELIGIBILITY FOR ENTRY

Entries are limited to two (2) per chapter.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

While this is not a "timed" event, all schedules must be adhered to as presented in "Specific Regulations" and "Procedure" sections.

V. SPECIFIC REGULATIONS

A. Posters can depict any safety procedure/concept as long as it relates to some phase of Industrial Arts. All posters are to be a hanging type of cardboard or poster board.

B. Maximum size is limited to 24 inches by 36 inches. Total cost of materials in the production of the poster shall not exceed $5, and a list of costs must be neatly printed on the reverse side.

C. Contestants must not leave posters until entry numbers have been affixed on the back of their posters by an official. The entry number will be assigned during contest registration. Contestant's name, school, etc. must not be on the poster during judging.

D. Entries must have been started <u>after</u> the past National Conference competition.

VI. PROCEDURE

A. Registration - Contest participants must register for the event in accordance with procedures established for each conference.

B. Posters must be entered during the assigned contest entry time. Late entries will not be accepted.

C. Posters may be picked up only at the assigned time.

D. All winning safety posters become the property of TSA, Inc. for a period of one year, to be utilized as deemed appropriate by the corporate board members.

VII. REQUIRED CONTEST PERSONNEL AND EQUIPMENT

A. Contest Coordinator to collect posters and position posters for judging per level.

B. Two (2) persons to register entries and place entries on the easel.

C. Three (3) judges per level.

D. Display easel for each level to be placed 10-15 feet from the judges.

VIII. CRITERIA AND JUDGING

A. Contestants shall be ranked in numerical order on the basis of final score to be determined by each judge without consultation with each other. The winner will be that contestant whose total score is the highest. Other placings shall be determined in the same manner.

B. Ratings will be based upon the following:

1.	Eye Appeal	20 points
2.	Safety Content Validity A measurement of the entrant's ability to present a valid safety theme for an Industrial Arts Classroom . . .	20 points
3.	Originality	20 points
4.	Organization	20 points
5.	Interest	10 points
6.	Neatness	10 points
	TOTAL	100 points

SCHOOL SHOP MAGAZINE TECHNICAL REPORT WRITING

OVERVIEW: TSA contestants in School Shop Magazine Technical Report Writing are required to read and analyze technical articles and write a comprehensive report summarizing the key elements of the articles.

I. CONTEST PURPOSE

The purpose of the School Shop Magazine Technical Report Writing contest is to provide a means for TSA members to demonstrate their ability to consolidate various information sources into a complete and comprehensive report.

II. ELIGIBILITY FOR ENTRY

No more than two (2) entries per chapter.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

The allotted time for preparation of the paper shall be one (1) hour. All contestants in this event must arrive and be "in place" at the specified time and place, since only one time frame will be designated for this event.

V. SPECIFIC REGULATIONS

A. Only a dictionary and thesaurus may be carried

into the contest area and be used in preparing the paper.

B. ALL contestants will begin after the instructions have been given and upon the signal of the Contest Coordinator. Late contestants will be disqualified.

C. Only contestants will be allowed in the contest area. No contestants will be allowed to leave the area until time has expired and papers are collected by the Contest Coordinator. Should a contestant finish before the allotted time, the contestant will keep his paper, remain seated, and not talk to or disturb any other contestant. Violators will be disqualified at the discretion of the Contest Coordinator.

D. A ballpoint pen and paper will be supplied by the Contest Coordinator and must be turned in at the conclusion of the contest.

E. Contestant's name, chapter, state, or other identifying information will <u>disqualify</u> that contestant's paper. Each paper will have the "Contestant Entry Number" placed in the upper right-hand corner of the first page, just above the title of the paper.

F. Length of the paper will be limited to ten (10) pages.

VI. PROCEDURE

A. Registration - Contest participants must register for the event in accordance with procedures established for each conference.

B. All contestants will gather at the identified location and time specified in the Conference Program. Those contestants arriving after the designated time will be disqualified and not be allowed to enter the contest area.

C. Given pen, paper, and three (3) technical articles on one topic, the contestant will prepare a technical report on that topic complete with bibliography.

D. All winning technical papers become the property of TSA, Inc. for a period of one (1) year, to be utilized as deemed appropriate by the corporate board members.

VII. REQUIRED CONTEST PERSONNEL AND EQUIPMENT

A. Contest Coordinator

B. Judges - a minimum of three (3) per level

C. A timekeeper for each level (unless held in same room and at the same time)

D. Materials and equipment supplied for judges or contestants

1. Tables and chairs for judges.
2. Tables and chairs, or table armchairs for contestants.
3. Clock for timekeeper.
4. Securable room for each level (preferable) during time of contest. Levels may be staggered to accommodate contestants to be served in a smaller area. However, if this is done, each contestant must be notified of their participation time.
5. Judges' rating sheets.
6. Ten to twenty sheets of paper per contestant.
7. One ballpoint pen per contestant.

VIII. CRITERIA FOR JUDGING

A. Each contestant's paper will be reviewed and scored by each judge for that level, without consultation with each other. The winner will be that contestant whose total score is the highest. Other placings shall be determined in the same manner.

TECHNOLOGY PROCESS DISPLAY

OVERVIEW: TSA chapters entering the Technology Process Display contest are required to construct and display an industrial or technological process within a defined area.

I. CONTEST PURPOSE

The purpose of the Technology Process Display contest is to provide a means for TSA chapters to demonstrate their knowledge of a process which they have researched by fabricating a display of the researched process.

II. ELIGIBILITY FOR ENTRY

A. Only TSA chapters in good standing are eligible for entry.

B. Each chapter that is eligible may enter one display or exhibit for competition at the national contest level during the annual convention.

C. One entry per level.

III. LEVELS OF COMPETITION

Level I and Level II as described in General Rules.

IV. TIME LIMITATIONS

While this is not a "timed" event, all schedules must be adhered to as presented in Section V and VI.

V. SPECIFIC REGULATIONS: A violation of regulations A or B will disqualify entry.

A. The exhibit size may not exceed 4' x 4' x 8' high.

B. The exhibit must depict some industry, industrial process, operation, or application of methods or processes used in industry. (Applications of new technology to solve technical problems are encouraged.)

VI. PROCEDURE

A. Registration - Contest participants must register for the event in accordance with procedures established for each conference.

B. Exhibit must be entered during the assigned contest entry time.

C. Contest Coordinator must attach an entry number in the lower right corner of the exhibit. The contest number will be assigned during contest registration.

VII. SUPPLY LIST

A. Personnel

1. Contest Coordinator
2. Judges, three (3) per level
3. Helpers, two (2) per level

B. Equipment

1. Contest guidelines (3 per level)
2. Judges' rating sheets
3. Marking pens for judges, 12
4. Display tables for technology process display (a minimum of twelve 4' x 8' tables per level)
5. Table and chair for judges (3-person workstation per level)
6. List of entries

VIII. CRITERIA FOR JUDGING

A. The exhibit must be a chapter project.

B. Each exhibit shall have a description of the industry or industrial process it depicts. The number of chapter members participating in the total exhibits shall also be noted.

C. No student or advisor will be allowed to stand by exhibits during judging.

D. Rating will be based on the following:

1.	Organization	20 points
2.	Originality	20 points
3.	Subject Coverage	30 points
4.	Interest and Appeal	15 points
5.	Workmanship	15 points
	TOTAL	100 points

STUDENT GROUP PRESENTATION

OVERVIEW: For each unit there are blocks of information that can be developed and presented by the students. Such information as component identification and selection criteria of welding consumables lends itself to student presentations. The information regarding safety and safety equipment also can be addressed in a student presentation format. These presentations should include demonstrations which utilize bulletin board displays and wall charts.

Note: Charts should be of a given size for framing, and should be framed, covered in glass for protection, and displayed in the laboratory during a time period that addresses that unit. The size criteria could enable the use of one set of frames.

GROUP ACTIVITY

OVERVIEW: There are five major welding units to be presented during the course of the school year--Oxygen Fuel Gas Welding, Oxygen Fuel Gas Cutting, Shielded Metal Arc Welding, Gas Tungsten Arc Welding, and Gas Metal Arc Welding.

Mechanics:

1. Divide class of approximately 20 students into four equal groups.

2. The instructor will then be responsible for the first unit. This will enable the student groups to learn what will be expected of them.

3. Each student group will then be responsible for one major welding unit.

Ways to approach group selection:

1. Student Involved Groups. This type of group utilizes friendships. This group may or may not develop the best product.

2. Teacher Assigned Groups. This method gives the teacher more control to adjust the complexion of the groups by judgmental assignment--over achievers and under achievers.

3. Random Selection Groups. Have the class count by fours. Assign all of the same number to the same group. This method lessens the instructor's control over the final product.

Note: Whatever method of group selection is used, it is suggested that the first activity of the group be to select a group leader. The group leaders may be appointed by the instructor, but it is often more productive to let each group select their own group leader. The group leader concept simplifies instructor/student communication. Also, to simplify matters, it is suggested that remaining units be numbered and each group leader draw a number "out of a hat" at random to determine which group has which unit.

Grading:

1. A checklist should be used to make this task manageable.

2. A numerical grade can be assigned as a group, but individual efforts should be recognized.

3. It is suggested that photographs be made of all displays presented. These should then be judged by a third party as to their effectiveness.

4. A composite of the scores given by the instructor and third party will be used to determine an overall winner.

5. This group will be awarded something special in addition to their grade and praise.

Note: An informal survey of a group of teenagers suggested that a lunch at a local pizza parlor during school time would be incentive to do a good job on the project. Often, the principal is asked to be a judge of the final project. This allows for approval by a higher authority. There has to

be administrative support for this project. Any objections can be overcome with the proper presentation to the administration.

As far as costs go, the local supplier of welding equipment may contribute something towards this project.

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Books

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Equipment and Supplies

Eutectic and Castolin Institute
40-40 172nd Street
Flushing, NY 11358

Hobart Brothers Company
P. O. Box EW-495
Troy, OH 45373

Miller Electric Mfg. Co.
P. O. Box 1079
Appleton, WI 54912

Sellstrom Manufacturing Co.
P. O. Box 355
Palatine, IL 60078

The Lincoln Electric Co.
22801 St. Clair Ave.
Cleveland, OH 44117

Union Carbide Corporation
Linde Division
270 Park Avenue
New York, NY 10017

Victor Equipment Company
P. O. Drawer 1007, Airport Road
Denton, TX 76201

Wilson Sales Company
P. O. Box 3155
South El Monte, CA 91733

Magazines/Journals

Industrial Education Magazine
Cummis Publishing Company
26011 Evergreen Rd.
Southfield, MI 48076

School Shop Magazine
Prakken Publications, Inc.
P. O. Box 8623
Ann Arbor, MI 48107

Stabilizer
The Lincoln Electric Company
22801 St. Clair Ave.
Cleveland, OH 44117-1199

The Technology Teacher
The International Technology Education Association
1914 Association Drive
Reston, VA 22091

VOC ED
The American Vocational Association
1410 King Street
Alexandria, VA 22314

Welding Design & Fabrication
Penton Publishing
1100 Superior Ave.
Cleveland, OH 44114

Welding Innovation Quarterly
The James F. Lincoln Arc Welding Foundation
P. O. Box 17035
Cleveland, OH 44117

Welding Journal
The American Welding Society
550 N. W. LeJeune Rd.
Miami, FL 33126

Audiovisual/Computer Software

AAVIM
120 Driftmier Engineering Center
Athens, GA 30602

Abraxas
P. O. Box 1416
Eugene, OR 97440

Apple-Swap
607 Sycamore
Starkville, MS 39759

Bergwall
106 Charles Lindbergh Blvd.
Uniondale, NY 11553-3695

Career Aids
20417 Nordhoff St. Dept. D2
Chatsworth, CA 91311

Curriculum Instructional Materials Center
1500 West Seventh
Stillwater, OK 74074-4364

DCA Educational Products, Inc.
P. O. Box 338
Bedminster, PA 18910

DRW Educational Systems
P. O. Box 2941
Costa Mesa, CA 92628-2941

Hearliky S. Co.
714 W. Columbia Street
Springfield, OH 45501

Hobar Publications
1234 Tiller Lane
St. Paul, MN 55112

Library Filmstrip Center
3033 Aloma
Wichita, KS 67211

McKilligan Supply Corp.
435 Main Street
Johnson City, NY 13790

Modern Talking Picture Service
5000 Park Street North
St. Petersburg, FL 33709

Sunburst Communications
Room M52
39 Washington Ave.
Pleasantville, NY 10570

Tel-A-Train, Inc.
P. O. Box 4752
Chattanooga, TN 37405

Vocational Media Associates
P. O. Box 1050
Mount Kisco, NY 10549-0050

Curriculum Labs

Mid-America Vocational Curriculum Consortium, Inc.
1500 West Seventh Avenue
Stillwater, OK 74074-4364

The National Center for Research in Vocational Education
2150 Shattuck Avenue, Suite 600
Berkeley, CA 94704-1304

Vocational Curriculum Development & Resource Center
P. O. Box 1159
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Education Associations

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1410 King Street
Alexandria, VA 22314

International Technology Education Association
1914 Association Drive
Reston, VA 22091

Louisiana Industrial Arts/Technology Education Association
40256 LaRochelle Drive
Prairieville, LA 70769

Louisiana Vocational Association
Sullivan Vo-Tech School
1710 Sullivan Drive
Bogalusa, LA 70427

Professional Welding Society

The American Welding Society
550 North West LeJeune Road
Miami, FL 33126

State Agency

The Louisiana State Department of Education
Office of Vocational Education
Industrial Arts Section
P. O. Box 94064
Baton Rouge, LA 70804-9064